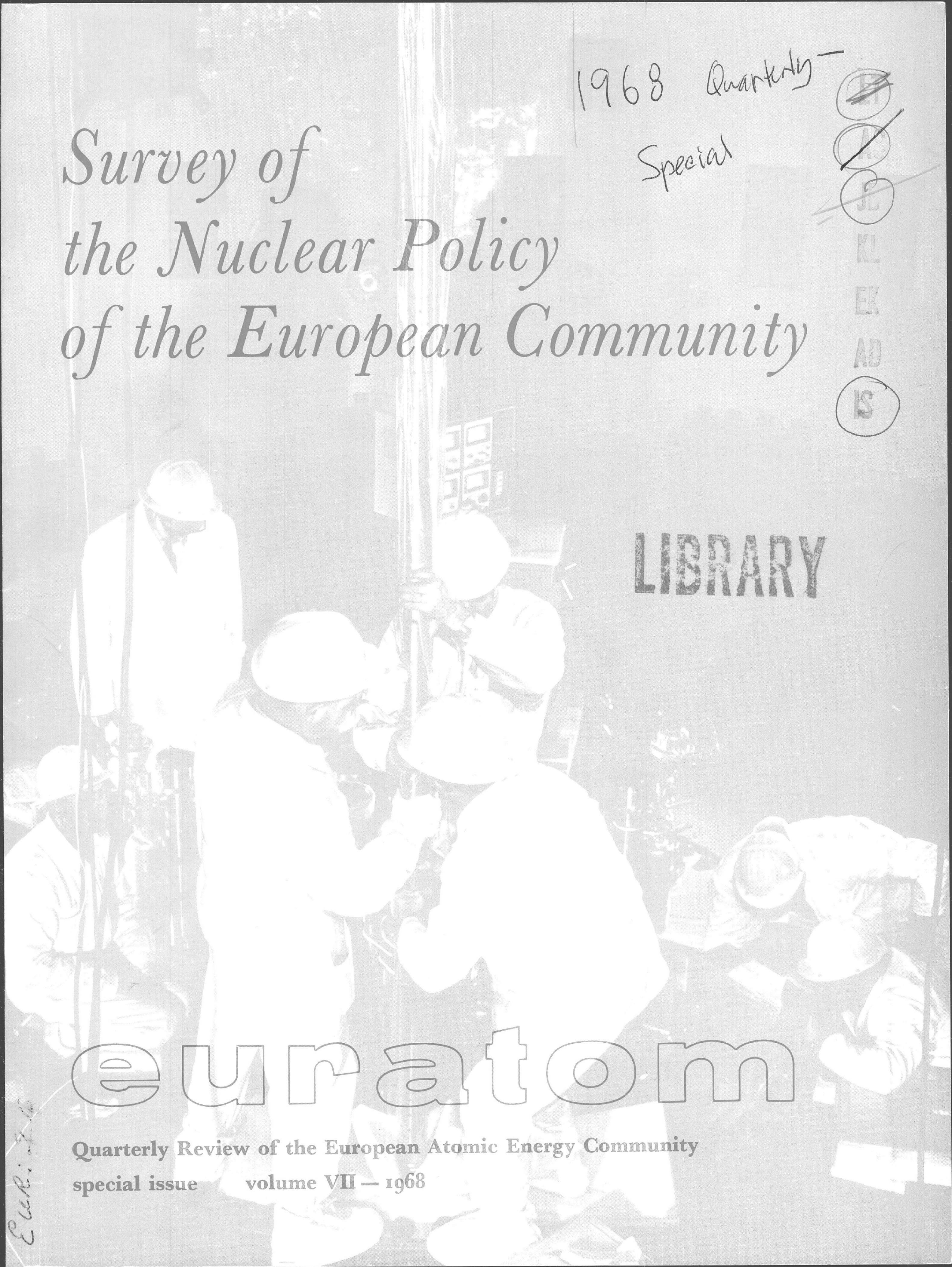

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Cover: *Erection work in progress on the top platform of the* ESSOR *reactor at the Ispra Establishment of the Joint Research Centre.*

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SURVEY OF THE NUCLEAR POLICY OF THE EUROPEAN COMMUNITY

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Survey of the Nuclear Policy of the European Community

This special number of the "Euratom Review" publishes, in a very slightly abridged version, the text of a communication from the Commission of the European Communities to the Council of Ministers. It consists of a survey of the Community's nuclear policy, its aim being to stress the disturbing nature of the current state of affairs, to identify the factors which underlie it, and then to draw the lessons from this analysis.

To those of our readers—and there is a considerable number—who have asked for more information on the nuclear policy of the Six, both at the national and at the Community level, we could not do better than make this document available. We feel that all our readers will find food for thought in it.

Introduction

The *European Atomic Energy Community* was established by a Treaty whose aim was to create favourable conditions for the growth of a powerful nuclear industry. Ten years later, however, it must be admitted that this objective is still far from being reached.

It is true that Euratom's own activities have often yielded good results within the limits imposed on this organisation, but on the whole the Community has not managed to co-ordinate the efforts of the member countries, even less to weld them into a coherent whole.

One of the obstacles to the creation of a genuine nuclear common market is the fact that research and development programmes within the Community have been unco-ordinated. Member countries have reserved appropriations and public contracts for their own domestic industries, and orders placed by the electricity utilities have been awarded solely to domestic contractors. As a result, the growth of the nuclear industry within the Community has not been furthered by the abolition of tariff barriers and quota restrictions following the coming into effect of the Euratom Treaty.

This state of affairs has inevitably led to the present crisis, which is not confined to Euratom but extends to nuclear development in the Community as a whole.

It is the aim of this report to elucidate the causes of this situation and to point out the lessons which emerge for future guidance.

In the nuclear sector, it cannot be argued that the Community has not made adequate sums available to research. So far from this, it is surprising to note that the effort of the Six, on both the national and Community levels, as regards public spending on civilian research, has been only marginally lower than in the USA, which means that it has been higher in proportion to the gross national product.

Although this fact must be treated circumspectly when it comes to assessing the efforts made by the US public sector since the Second World War, as well as the extent of privately financed research on that side of the Atlantic, it is nonetheless disappointing to observe that the industrial and commercial return on the financial outlay in Europe has been so low.

Thus, in spite of the much higher costs of conventional energy in Europe, the number of nuclear power stations under construction, on order or planned in the Community is only 16, representing some 6,500 MWe, in comparison with 87 units in the United States, representing some 70,000 MWe.

From the industrial point of view, it is also noteworthy that the 87 power plants in the USA are being or are to be built by four or five contracting firms, whereas the 16 units in Europe are being or are to be built by about 12 firms. The total value of the orders placed in the Community is less than that of the orders placed with each of the American firms.

These figures afford an idea of the extent of the remedial action required in this field.

Needless to say, a situation such as this cannot in any sense be ascribed to some hypothetical European inferiority in a sector which is well within the capabilities of European scientists. It has been caused by fragmentation of efforts the bulk of which has been pursued at the national level and with national objectives in view. The weakness of industrial structures within the Community is in fact the result as much as the cause of this lack of co-ordination of officially sponsored projects. However, this in its turn serves to accentuate the contrast between the quality of the scientific work and the meagre economic return from it.

Admittedly, in the present state of Community development, member countries are inevitably concerned to pursue certain objectives of their own in the nuclear sector. Even so, between this present state of affairs, marked by fragmentation breeding wastage, and the ideal situation, where there would be only one nuclear policy in the whole Community, several stages are possible. What is of paramount importance as things now stand is that progress should be made.

Where the Community and its Member States are concerned, progress means mapping out jointly what might be called a "grand strategy" for nuclear development. Despite the enormous complexity of the difficulties to be faced, their fundamental data can be stated in quite simple terms.

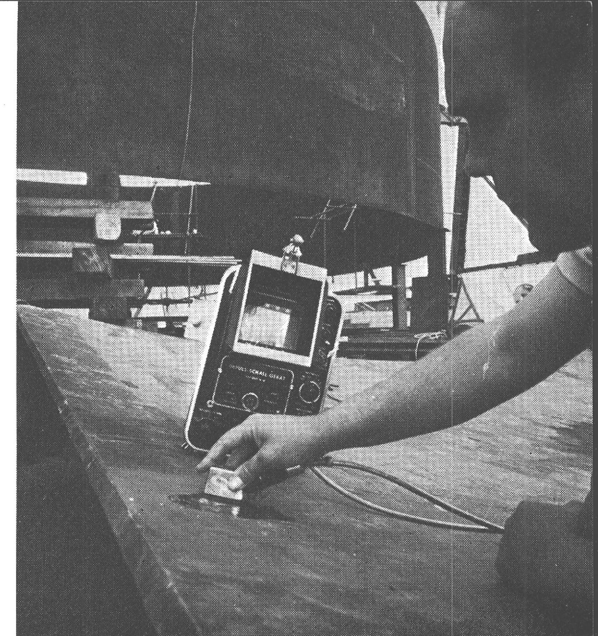
1. The basic factor is nothing more nor less than the long-term necessity to make sure that the Community economy over the long term has the reliable and cheap supplies of power which nuclear ener gy promises to provide and thereby to open up a new field of industrial expansion in the Community.

The essential requirement today for reaching this goal is a concerted effort by the public authorities, the electricity producers and the power plant constructors. To rectify the situation, it is not enough to organise research on sound lines; industrial structures must be modified by rationalising the demand for nuclear power stations and by encouraging closer integration and specialisation among enterprises on a multinational scale. The public authorities could usefully contribute to nuclear development by covering certain exceptional risks peculiar to the nuclear sector.

2. A policy of nuclear development also involves a policy of reactor development. Here fragmentation is currently the most damaging factor and must be gradually reduced at the cost of sacrifices demanded by tough political compromises. The Community cannot afford the luxury of developing half a dozen types or variants of the heavy-water or high-temperature advanced converter reactor up to the industrial stage and at the same time proceeding with two or three distinct projects in the more distant though promising field of fast breeder reactors.

3. Whatever the decisions necessitated by the establishment of a well-knit reactor development programme, there can no longer be any two opinions about the need to provide the Community with access to a source of enriched uranium. Thus there arises the problem of building in Europe an isotope separation plant which would be of sufficient size to produce enriched uranium at moderate cost, and by the same token there emerges the opportunity for joint action in a vital sector.

4. The lack of a genuine common policy for nuclear development has produced a situation in which the Community is reduced to adding its own programme to those of its member countries, and hence Euratom has been called a "seventh power".



Checking a weld by ultra-sonics on the site of the Würgassen nuclear power plant in Germany.

Overall co-ordination is obviously necessary. Under Article 5 of the Treaty, this would mean that the Commission would receive full details of all research programmes drawn up in the Member States and that these programmes would be subjected to a searching examination so that all nuclear research in the Community became part of a single integrated programme.

5. The attempt to strike a balance between the benefits and sacrifices of each member country in the form of "fair returns" on a sectoral and budgetary basis resulted in abuses which are too well known to need reiteration.

It could lead to a progressive contraction of the Community's activities in all fields, as each Member State tends to pull out of sectors offering it no great advantage. The truth is that the only satisfactory solution to the problem of "fair return" lies in overall compensation.

By making use of the Treaty provisions concerning joint enterprises, it is possible to arrange every conceivable apportionment from among the participants, and at the same time ensure co-ordination of all the Member States' efforts.

Other research projects could be made complementary programmes without the joint enterprise formula necessarily being employed. This should not, however, become a regular practice. Besides, any complementary project, whether it takes the form of a joint enterprise or not, should be linked to the common programme, and to this end it should fulfil two basic conditions:

— effective participation by the Commission;

— guaranteed dissemination of information, which should be as wide as possible, with due regard to the constraints imposed by industrial property rules.

However, the implementation of these provisions would not obviate the risk of fragmentation unless they were based on a joint programme of sufficient substantial content to counteract any tendencies in this direction.

6. The establishment of a single integrated policy covering all aspects of nuclear development could lead to the exploitation of at least part of the Community's existing potential on new lines. If this is done as part of an overall comparison and harmonisation, the *Joint Research Centre Establishments* should also participate in it. Reorganisation of national or Community research bodies must not result in the sacrifice of basic research, essential to subsequent technical progress, or of programmes not concerned with electricity production (study of materials, solid-state physics, direct production of industrial heat, controlled thermonuclear fusion, biology, etc.).

Nor must one rule out the orientation of certain potentials towards non-nuclear research, and in particular towards research in communications (data processing, computer language, systems compatibility), materials and biology, and their applications. Where the potential of Euratom is concerned, however, all this is subject to the prior conclusion of a legal agreement necessitated by such a reorganisation as this.

The lines of action resulting from the proposed harmonisation will guarantee the optimum utilisation of the personnel who are the driving force behind research programmes in the Community and who constitute a potential the fragmentation of which would be highly regrettable.

7. Concentration of efforts is insufficient in itself, however. There is a further need in the Community to create the most favourable conditions possible for research and innovation in all fields. These are problems which transcend the nuclear field, but which are none the less fundamental.

There is no mobility of ideas without mobility of manpower. National barriers are not the only ones to blame. Other barriers should be lowered—such as those in Europe which still in far too many cases isolate universities, government research centres and individual firms, or those which stand between numerous international organisations which are financed by the same sources but which lack a common supervisor.

Furthermore, projects would have to be implemented which were as vital to nuclear development as to scientific, technological and general industrial development, such as European status for companies, the elimination of administrative and fiscal obstacles to international mergers, the European patent and the common market for capital.

The Commission is convinced that the continued disagreement on the future activities of Euratom is liable to have the most serious consequences not only in the nuclear sector, but also in other fields of Community activity.

In Euratom's case, if this disagreement were to persist, it would lead to the disruption and cessation of Community research programmes before even the lowest level of co-ordination of domestic programmes could be established, and before Community industries in the nuclear field could be set on the road to profitability. Thus the wastage of public resources, and the even more reprehensible wastage of brain-power, would remain unchecked. At the same time the fencing-off of the market for nuclear power stations would continue to hinder any competitive industrial development in this sector.

Nuclear researchers would doubtless continue to make scientific and technological discoveries; the industry would doubtless continue to function with the aid of state subsidies; with government support it might even manage to have several new power stations installed in the grid system by domestic electricity producers, using the country's own type of reactor; and also it would doubtless succeed in "selling" several other types abroad by means of aids, guarantees and long-term credit facilities. But in the long run, foreign techniques would be accepted in Europe as elsewhere, by reason of the inherent advantages offered by the size of the international market.

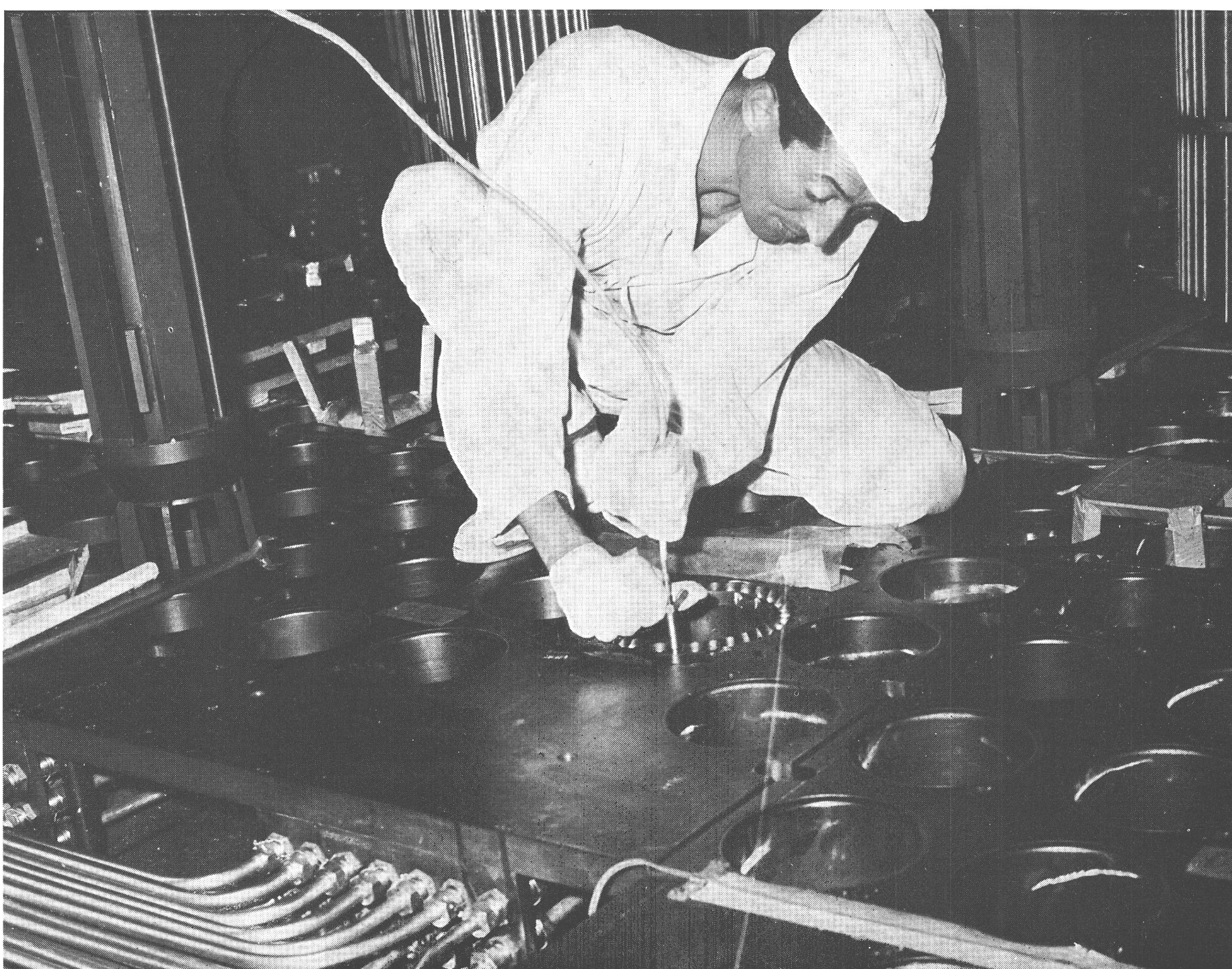
This is what is at stake for Euratom for the immediate future. Either the member countries make progress towards true co-operation, which is impossible without a certain degree of integration of efforts, or they will have to relinquish all hopes of holding their own in the large-scale industrial competition which in the next few decades will be brought about by the production and sale of super power stations.

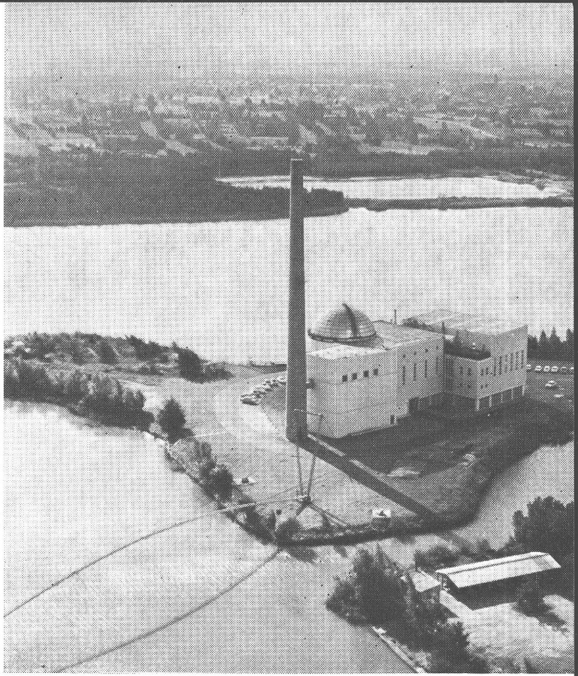
The Commission also feels constrained to draw the attention of the Council to the repercussions which the Euratom crisis could have in other fields if it were to continue. Inability to make progress in a sector of advanced technology where the basic structures are not yet wholly consolidated would certainly prejudice the chances of establishing a common policy for technological and industrial research and development, both in the other leading sectors and in the traditional sectors. The dissolution of Euratom could even be taken as an excuse for attacking other recipients of Community finance.

The aim of the first part of this document is to develop this analysis, basing it on fact and taking into consideration not only the problems of research and technology, but also those of energy and industrial development. The second part contains the details of guidelines which should, in the opinion of the Commission, be adopted in the same sectors in order to remedy a situation which has already deteriorated to a dangerous extent.

This report does not consider the other very important tasks such as education and training, health physics and safeguards and controls, all of which were entrusted to Euratom. What has been accomplished in these sectors is sufficiently satisfactory for the present report to confine itself to analysing the problems relating to energy, industry and research.

Shot taken during erection of the Latina gasgraphite power reactor (Italy).





The BR3 *power reactor at Mol.* (*Belgium.*)

Part 1 Critical Analysis of Nuclear Development in the Community

Chapter I

ENERGY ASPECTS*

1. Growth of energy needs in the Community

For about twenty years, all six of the *European Economic Community* countries have been experiencing a steady economic expansion which has manifested itself largely in a rapid increase in energy consumption. In terms of primary energy, consumption rose from 389 million tce (tons of coal equivalent) in 1955 to 635 million in 1967. The mean rate of growth over the whole of this period comes to about 4.25% per year.

It may well be asked whether this advance, a necessary condition for the maintenance of economic expansion and the improvement of living standards in the Community countries, will persist at the same pace over a fairly long period. In this event, overall energy consumption would reach about 1,100 million tce by 1980.

In the overall energy picture, electrical energy displays particular vitality. During the last ten years, its rate of increase has averaged more than 7% annually, or, in other words, demand has doubled in ten years. All the indications are that this rate of growth will be maintained. If further evidence is required, per capita consumption in the Community countries might usefully be compared with that in the USA for 1966, i.e. 2,120 kWh against 5,820 kWh. It follows that the share of electricity in the total energy comsumption will rise from its present level of a quarter to a third in 1980.

From 186,000 million kWh in 1955, net consumption climbed to 440,000 million kWh in 1967. It is thought that it will be of the order of 1,100,000 million kWh in 1980. Similarly, the primary energy required for producing the necessary electricity amounted to 100 million tce in 1955 and 165 million tce in 1967. In 1980, therefore, it should be approaching 350 million. When this level is attained, power plants in the Community will be consuming more than double the volume of fuel used at the present time.

The magnitude of the increases in demand which will have to be faced in the near future means that intensive use will have to be made of all sources that are available in sufficient quantity, are of satisfactory quality and are obtainable at reasonable cost. The Community will find it increasingly difficult to meet its needs from its traditional indigenous resources and at the same time acquire supplies on economically acceptable terms. In point of fact, the Community, which imports a little over half of its energy requirements, will be dependent on outside sources for about 55% of them in 1970, and perhaps as much as 62% in 1980.

2. The contribution of nuclear energy to the implementation of a common energy policy

In this context, nuclear energy can make a major contribution to the realisation of the two primary aims of the common energy policy as defined in the "Protocol of Agreement on Energy Questions" of 21 April 1964, which was adopted by the representatives of the Member State governments at the Council of Ministers. These aims are:

— to secure the lowest prices,

— to guarantee dependability of supply.

It should be emphasised that the same Protocol, referring to nuclear energy, recommended that "this new energy source should be enabled to make a maximum contribution as soon as possible, and in economic conditions, to covering the Community's energy requirements."

As far as electricity prices are concerned, nuclear energy is at present the only leading source of electricity production in a position to ensure that prices per kWh will follow a downward trend in the future.

It is now an established fact that nuclear energy can generate power cheaply and that its ability to compete on favourable terms with conventional sources is true of the large 600-800 MWe plants equipped with proven-type reactors of the present generation. Furthermore, it may be expected that the cost per kWh will continue to decrease because of the improvement potential of proven-type reactors.

Succeeding generations of reactors, "advanced converters" and "breeders", make it certain that this tendency towards a reduction in the cost per kWh will be continued.

On the other hand, intensive recourse to nuclear energy represents an important factor in dependability of supply. While nuclear energy is not an exclusively indigenous source, it has a considerable number of advantages compared with other energy sources imported for the production of electricity, notably the appreciable geographical diversification of supply resulting from the traditionally stable commercial relations which the Community enjoys with the natural-uranium exporting countries, the capacity of the fissionable substances in reactors to produce electricity for a fairly long period without refuelling and the fact that requirements of fissionable materials can be reduced in the medium and long term by using reactor types offering a higher energy yield.

3. Market prospects for the nuclear industry

In the United States, where preoccupations with low-cost energy and supply are less acute than in Europe, nuclear energy

* The Commission is here endeavouring to illustrate against a general background the different aspects of a nuclear policy; in this context, it has been necessary to anticipate to some extent the Commission's ideas on energy policy. This does not in any way mean that the Commission intends to adopt a sector-by-sector approach when setting forth its energy policy proposals.

shows a rapid expansion. This trend underlines the economic advantage of this source of energy.

In 1966 and 1967, nearly half the power plants ordered were equipped with nuclear reactors. Forecasts put the installed capacity in 1980 at 170,000 MWe. Even if the installed nuclear capacities at present total only about 2,300 MWe both in the United States and in the Community, the capacity of the nuclear power plants under construction, on order or planned amounts to 70,000 MWe in the United States as compared with a mere 6,500 MWe in Europe.

Nevertheless, the rising curve of electrical energy requirements on the one hand, and the inherent advantage of nuclear energy as a cheap and stable form of energy on the other, should in the normal course assure it of a considerable market in the Community.

Despite the market prospects which lie before it, the fact has to be faced that the rôle of nuclear energy in Europe has hitherto been a very modest one.

Accounting at it does at present for barely 2% of electricity production, nuclear energy is making a much smaller contribution than that envisaged a short time ago. Current projects awaiting completion represent as yet only a relatively minor step forward. It will be noted by way of comparison that in the United Kingdom 15% of electricity production is already derived from nuclear sources.

4. The causes of the lag in the development of nuclear energy in the Community

The relative stagnation of the Community in the nuclear field may be explained by a combination of factors, the first of which concerns the necessary scale of the projects. Because of the present position as regards profitability in the field of nuclear energy, electricity producers are obliged to consider only the installation of units with ratings of 600-1,000 MW, depending on local conditions. At the same time, the decrease in capital costs as a result of the increase in size is more marked for nuclear power plants than for conventional plants. The integration of nuclear units of this size still poses technical and financial problems, the size of the plants being determined by the power and density of the distribution network.

On the other hand, the very structure of the electricity production industry differs from country to country in the Community. In two countries (France and Italy) the means of production are nationalised, while in the other Member States they are in the hands of private, public or mixed-type enterprises.

The solution of these problems, together with the vast investments required, is generally beyond the scope of the regional or national bodies called upon to deal with them in the present circumstances.

A second factor hampering development consists in the operational risks involved in any new technology, which in the present case are to a certain extent inhibiting the electricity producers from venturing into the nuclear field at this stage. Hence it is that the reliability of nuclear installations assumes an importance equal to that of the level of costs, and only through the accumulation of experience at the industrial level will it be possible to allay this anxiety regarding operational safety.

The uncertainty, although relative, which persists concerning the respective merits of various types of industrially proven reactors, as well as the much more serious uncertainty as to the economic advantages and the development schedule of future reactors, makes electricity producers delay taking decisions on investment, especially as the nuclear sector as a whole is experiencing rapid technical progress.

It is in this light that one must study the problem of incorporating into the grid reactor prototypes which offer the best opportunities of lowering production costs. This necessary link between production of electricity of nuclear origin and advances in research calls for joint action in the field of prototypes, with a concentration of the efforts of the industry in the best conditions as regards the choice of techniques and also the still necessary backing of the public authorities. After all, it cannot be expected either that a single producer will bear all the risks inherent in operating a prototype or even, perhaps, that associations between constructors and operators can dispense altogether with government aid.

A third factor in the delaying of orders for nuclear equipment in the Community consists in the uncertainties surrounding the supply of nuclear fuel. Naturally, the problem varies according to reactor types. It will be one of the aims of a concerted strategy to lessen the extent of this problem. The Community, in fact, possesses in its territory only a small proportion of the nuclear fuel needed to satisfy its requirements.

At the same time, the portents are of a world market subjected to certain pressures necessitating an intensified quest for new uranium deposits. At present it must be admitted that the efforts of European industry in this field are not up to the scale of the Community's requirements. In fact, expenditure devoted to prospecting by Member States represents no more than roughly a tenth of world expenditure in this sector, while the ratio of the Community's nuclear fuel requirements to world requirements is of the order of one to five.

To be assured of supplies which are consistently available in quantity and stable in price is a major factor in the electricity producer's decision, and as such demands attention.

In addition to these considerations where natural uranium is concerned, there is the problem of availability of enriched uranium. At the present time, the only commercially available production comes from the United States. The European electricity industry is looking into the technical and economic implications of such a monopoly.

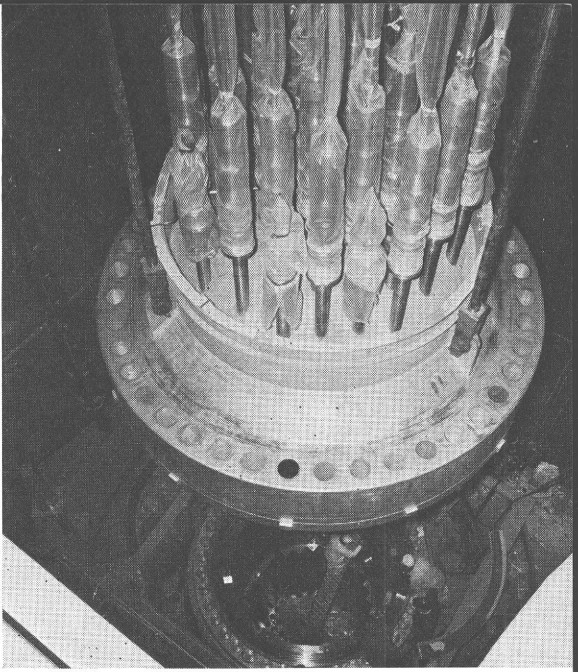
This anxiety seems especially significant and well-founded when it is remembered that in 1980 nuclear energy will already account for nearly 25% of electricity production.

Whatever the guarantees granted by the American government regarding price and supply, it will no doubt become apparent upon completion of the current studies that at least part of the Community's enriched uranium should be provided by an isotope separation plant set up in the Community and capable of operating at reasonable cost.

In connection with the question of supply, the Euratom Treaty, which assigns to the Community the task of safeguarding the supply of nuclear fuel to Community users, provided for the inception of a limited common supply policy with regard to prospecting in the territory of Member States.

In addition, the Treaty set up a Supply

Assembly of the pressure vessel for the Franco-Belgian power plant at Chooz in the Ardennes (SENA).



Agency—a body empowered by a special status to act in commercial matters. The principal aim of the Agency was to guarantee users equal rights of access to the internal and external resources of nuclear materials. This aim was in line with the conditions of relative scarcity prevailing at that time. It ceased to have any relevance with the trend towards the conditions of plenty in the sixties and the need for long-term development of resources.

The lack of agreement among the Member States on the modifications to Chapter VI introduced by the Commission in 1965 has resulted in a deleterious suspension of the efforts already in progress to arrive at a common policy.

All the Community's activities in this field must therefore be adapted to the new market conditions and the Community's supply requirements as soon as possible. This calls for both a broader and a geographically more extensive approach in the Community's areas of operation and the adoption of the Supply Agency as the commercial instrument of a common policy.

As has been seen, the slowness in the development of nuclear energy is due principally to problems of size, supply availability and experience.

The solution to the problems in these three categories would be considerably facilitated by the existence of a European-scale market for nuclear energy. What is needed is to initiate a series of intra-Community activities calculated to form a springboard for the development of genuine co-operation between the sectors concerned in the various countries. This would put an end to the current practice of setting up artificial markets solely with a view to putting pressure on known tenders, a practice which destroys any chance of associations and crystallises a country's isolationist position.

Agreement by the electricity producers of the various countries between themselves and with power plant constructors on the question of the phasing of their projects, in order to achieve the greatest possible rationalisation of their orders without restriction at the national level, would contribute to resolving the problems set out above.

An attempt in this direction was made by the Euratom Commission who, in accordance with Article 40 of the Treaty, published in the *Journal Officiel* of 28 April its First Target Programme, aimed at specifying the nuclear energy production goals and establishing what investments are necessary.

Bearing in mind the recommendations of the Agreement Protocol of April 1964, which were aimed principally at ensuring the availability of supplies at low cost and on as regular and stable a basis as possible, this programme advocated the installation in the Community between now and 1980 of a minimum of 40,000 MWe of nuclear capacity, which would probably be sufficient to satisfy a quarter of the demand for electrical energy, this according to a development model; the use of proven-type reactors, supplemented by advanced converters and, towards 1980, the gradual installation of fast breeders, was envisaged. This conservative estimate would mean that in 1980 nuclear energy would be providing 8% of overall energy requirements and 25% of electrical energy production.

It would no doubt be advisable to review the details of the development model chosen by the Euratom Commission, but it is essential to ensure that the preparation of programmes of this sort fulfils the rôle laid down for the Commission by the Treaty, namely, to facilitate development and coordinate investment. Close liaison between the parties concerned with establishing the objectives represents a first step in this direction. Comparison and discussion of their projects with the Commission are in themselves a step towards the implementation of the aims of Article 40.

It should be noted that, as well as its generating uses, there are other possible applications for nuclear energy, the production of heat and industrial steam for the heavy chemicals industry, for example.

5. Conclusions

The absence of an energy policy has been one of the factors in the lagging behind of nuclear energy. That nuclear electricity programmes have not been co-ordinated is a matter for legitimate regret, as this would have focused attention on the contribution of nuclear energy in the production of electricity.

The resulting lack of co-operation beyond the bounds of the various public and private sectors has prevented a real market on a Community scale from coming into being.

The operational risks which the utilities have to face stem from the advanced, constantly progressing technology of nuclear reactors on the one hand and the considerable size of the installations on the other. Whether nuclear energy will come into its own or not hinges entirely on the degree of sophistication achieved and the guarantees of reliability that the industry will be able to confer on the design and construction of reactors.

In addition, it is clear that the integration of nuclear power plants will, by virtue of their size, require a strengthening of transmission lines and an expansion of interconnecting systems.

With the prospect of a rapid increase in consumption of fissionable material and the supply problem inherent in this situation, it must be realised that the provisions of Chapter VI of the Euratom Treaty are scarcely appropriate.

Chapter II

INDUSTRIAL AND TECHNOLOGICAL ASPECTS

The previous chapter demonstrated the modest nature of the market open to the Community's nuclear industry until now and the hopes that may be engendered for it by the increase in the demand for electricity and the advantages offered by nuclear energy as a means of meeting it.

The question which arises here is whether the Community's nuclear industry is in a position to make its contribution towards raising electricity production and to meet international competition.

Answering these questions implies making an analysis of the state of the market, the industry and the development of nuclear technology in the Community, and this is the purpose of this chapter.

The analysis will cover the present state of the market for nuclear power plants, the structure of the companies and the public authorities' actions aimed at sponsoring the industry. In each of these sections the object will be to compare the position in the Community with that in the United States, where the development of the production of electricity from nuclear energy is very advanced.

1. The state of the market and of the development of nuclear technology

In reviewing the state of the market for nuclear power plants, a distinction will be made between those now being marketed industrially (proven-type) and those which have not yet reached this stage.

Proven-type plants

There are three types of plant either built or under construction in the Community, representing just over 6,300 MWe (spread over more than twenty units):

– two based on American techniques and licences (*BWR* and *PWR*), using enriched uranium,

– one developed virtually solely in France (gas/graphite) and using natural uranium.

(Italy also has a gas/graphite plant of British design.)

In the United States, by comparison, only two types of plant have been built, are under construction or are on order, representing about 60,000 MWe, spread over some hundred plants (*BWR* and *PWR*) and accounting for around one-fifth of present installed generating capacity. Most of these plants have ratings of over 600 MWe, and those most recently ordered, which will be handed over after 1974-75, are (twin or triple reactor) plants with a unit power of the order of 1,000 MWe.

The total value of orders exceeds \$ 6,000 million. In contrast, orders placed in the Community amount to some \$ 700 million, calculated on the same basis.

American utilities are currently covering about half of their new capacity requirements by orders for nuclear plants. If this trend is maintained, it can be expected that a capacity of about 170,000 MWe will be installed between now and 1980.

The total potential Community market up to 1980 open to reactors in this category is about 40,000 MWe.*

Calculated on the same basis as for the United States, this amounts to business worth at least \$. 4,000 million For the Community, this potential market represents annual orders for four or five plants of 600 to 1,000 MWe up to 1980.

One of the problems of reactor development in the Community lies in the separate emergence of two families of proven reactors (gas/graphite and light water). This dual development, which is due to special situations which existed in the past and persists mainly for reasons relating to the supply of enriched uranium, has up to now prevented multinational co-operation—so important to the production capacity of the Community's nuclear industry—between the industries of the Community in the field of proven-type reactors. Gas/graphite plants do not, however, appear to be competitive with light-water plants at the present time. Thus the United Kingdom, which also plumped for natural uranium (building 26 gas/graphite plants totalling 5,700 MWe), three years ago turned to advanced gas reactors using enriched uranium, while at the same time the Franco-German project for a gas/graphite plant was cancelled. The French government is currently reviewing its future nuclear energy policy for the same reasons, on the basis of the report of the *PEON* Committee.

Advanced (high-temperature gas and heavy-water) plants and fast breeders

In the Community there is even greater dispersion and lack of co-operation between nations with regard to unproven reactors which are currently being studied or developed with a view to their industrial application. These break down as follows:

– four variants of the heavy-water reactor (heavy water/heavy water, heavy water/light water, heavy water/gas, heavy water/organic);

– two variants of the high-temperature gas-cooled reactor (*Dragon*-type and pebble-bed reactors);

– two variants of fast reactor (sodium-cooled and steam-cooled).

Heavy-water reactors: five prototype or test reactors have been built or are under construction *(EL-4, MZFR, KKN, ESSOR, CIRENE)* in the Community by six firms. In the United States this family has been discarded by the *AEC*, while only one variant is being studied in the United Kingdom (heavy water/light water). Canada, on the other hand, is directing its whole programme towards this type by developing the heavy water/heavy water and heavy water/light water variants on an industrial scale. Sweden and other countries have also developed this family.

High-temperature reactors: two types are being studied at the present time: *Dragon* and the pebble-bed reactor.

A group of European firms have formed an association in anticipation of the development and construction of *Dragon*-type reactors. They are the *TNPG* (British), *GHH* (German), *BelgoNucléaire* (Belgian) and *SNAM-Progetti* (Italian). Two German firms (*BBC* and *Krupp*) have a joint interest in the pebble-bed reactor.

Negotiations have been opened with a view to setting up a second multinational association concerned with this type.

Only one firm in the United States (*Gulf General Atomic)* is engaged on high-temperature reactor work. It has built a test reactor (Peach Bottom, 40 MWe), is constructing a 330 MWe plant (Fort St. Vrain) and recently drew up a turnkey bid for a 1,000 MWe plant.

Fast breeder reactors: in the Community efforts are at present concentrated on sodium cooling, although steam cooling has not yet been discarded. Moreover, a commercial family of high-temperature gas thermal reactors could ultimately lead to high-temperature gas cooling of fast reactors. Following the joint development with Euratom of the *RAPSODIE* test reactor and the *SNEAK* and *MASURCA* critical assemblies, three designs are now being pursued independently. Germany, the Netherlands and Belgium on the one hand and France on the other are developing two competing prototypes: the 300 MWe *SNR (Siemens, Interatom, Neratoom* and *Belgo-Nucléaire)* and the 250 MWe *PHENIX (CEA, EDF* and *GAAA)*. In addition, Italy has decided to construct a fuel-testing reactor *(PEC)*.

* In comparison it is worth noting that the Community's consumption of electrical energy is one-third that of the US.

Fuel elements for the Lingen nuclear power plant in Germany.

In the United Kingdom the construction of the 350 MWe *PFR* prototype reactor has reached a very advanced stage and a decision has been taken to go ahead with the construction of a 600 MWe plant.

In the United States, which seems at present to be lagging slightly behind the Community, only three firms (*General Electric* on the one hand and *Westinghouse* and *Atomic International* on the other) are constructing two test reactors: *SEFOR** and *FFTF***. The active support recently extended to them by the public authorities and the utilities could give this sector a much-needed shot in the arm within a very short time.

The USSR, for its part, has decided to build a 600 MWe plant, and Japan is also taking interest in this type.

The development cost of an independent variant, from the outset to the first of the line, generally runs to $ 500 million or more. The funds required for the industrial-scale development of the different types of reactors and the limited size of the market are such that a choice must be made in order to ensure an economic return on the money invested. There are already plans in the Community to spend over $ 1,300 million on piecemeal development work on the various unproven reactor families.

The fuel cycle

The turnover of the companies that make up the fuel cycle industry is far from negligible. Thus it is estimated that, over the life of a plant, total expenditure on fuel is similar to, if not actually greater than, the capital costs. Accordingly, attention should be paid to the development of such an industry on economic grounds and for reasons of dependability of supply.

This applies to the three main industrial stages of the fuel cycle, namely, the supply of enriched uranium, the fabrication of fuel elements and fuel reprocessing.

a) *Supply of enriched uranium*

The enriched uranium used in the Community comes mainly from American enrichment plants. If this situation were to continue it might, in the long term, present serious disadvantages for the Community, notably if the United States' requirements were to soak up a larger proportion of their output. The construction of an enrichment plant, mentioned in the previous chapter, will be possible only at considerable cost and this could only be contemplated on a Community basis.

b) *Fabrication of fuel elements*

Only the two French companies *SICN* and *CERCA* show significant industrial output figures, their annual production capacity being 1,500 tons of natural uranium elements for gas/graphite reactors.

In conclusion it can be said that the size of the Community market is such that the large number of firms in the Community, if they remain dispersed, will certainly be unable to sustain industrial investments and to be in a position to give the guarantees necessary to face international competition.

c) *Fuel reprocessing*

Apart from facilities specially for the reprocessing of enriched uranium elements for research and materials-testing reactors (*EUREX* and, partly, *Eurochemic*, which was built under *OECD* auspices) the Community has the following facilities for reprocessing the fuel elements of power plants:

– France has two industrial plants for reprocessing natural uranium elements from gas/graphite reactors (Marcoule and Cap de la Hague);

– the major part of *Eurochemic's* activities and the German *WAK* facility now under construction at Karlsruhe are for reprocessing light-water reactor fuels.

Furthermore, the state of the reprocessing market is at present marked by very intense competition from companies outside the Community. The capacity of the Community's facilities easily meets requirements having regard to the relatively small number of power plants in operation. However, a change in the situation must be anticipated around 1975, when additional facilities will have to be brought into service, notably for low-enriched uranium fuel elements, unless a severe setback to the Community's independence in regard to this important link in the fuel cycle is accepted.

The nuclear power plant market in the Community has, therefore, the following salient features:

a) a small number of plants built, under construction or ordered;

b) a comparatively large potential market, on a Community level, for high-power plants but a limited one on a national level and if the number of constructors remains so large;

c) a large number of reactors designed, developed and built virtually independently in each country;

d) a high level of expenditure to date in relation to the economic returns obtained.

2. Structure of the nuclear industries

Nuclear energy is developed by close co-operation and constant interaction between three kinds of body, namely:

– the public authorities, as those responsible for political decisions, as budgetary authorities and as the operators of research centres;

– reactor constructors and component suppliers, who are also responsible for industrial research;

– electricity utilities as the future users of nuclear generating facilities.

Industry's rôle here varies from country to country.

In France, most of the work in the nuclear electricity sector has been carried out at the prompting of the public authorities (*CEA* and *EDF*). The choice of the type of reactor is made at government level. This being so, the French firms have come to collaborate with the authorities, which has enabled them to save by cutting out research of their own but makes them somewhat dependent on the authorities for new developments.

The construction of eleven power plants totalling 3,500 MWe of the gas/graphite natural uranium type of several research, test and prototype reactors has enabled the French industry to gain great experience in the manufacture of the various components.

* Built with backing by the Euratom/*GfK* Association.
** The *FERMI* reactor built by *APDA* should also be mentioned.

Several firms have joined forces to build or design reactors, and this collaboration has resulted in the setting up of specialist consortia.

The following are among the most important of these:

– the *Groupement Atomique Alsacienne Atlantique (GAAA)*;

– *SOCIA*, formed by an association of *Indatom* and *SEEN* and comprising some twelve major companies;

– *Framatome*, brought together under the aegis of the *Schneider* group and holder of a licence from *Westinghouse* for pressurised-water reactors;

– also noteworthy is the formation recently of the *SOGERCA* group, linking *Alsthom* and *Hispano Alsacienne*. Its aim is believed to be the negotiation of a licence agreement with *General Electric* with a view to building boiling-water reactors.

The first two groups and many other French firms have taken part in the construction of gas/graphite reactors and in the building of many experimental and test reactors of various types. In collaboration with *General Electric* and the Belgian firms of *ACEC*, *Cockerill Ougrée* and *MMN*, *Framatome* was architect-engineer for the 266 MWe Chooz plant. In addition *GAAA* formed an association with *Interatom* (Germany) and *Montedison* (Italy) for design work on the *ORGEL* family and the building of the *ESSOR* reactor; *Indatom* built the *EL-4* heavy water/gas reactor.

In West Germany, the reactor constructors *(AEG, GHH, Siemens, BBC-Krupp, Interatom)* are largely responsible for the development of reactors, which is financed mainly from public funds.

AEG and *Siemens* offer plants at fixed prices, on a turnkey basis. They act as independent architect-engineers and provide the required guarantees. These firms are linked by contract (licence or licence-exchange agreements, technical assistance) with big American firms. Through these contracts, whose conditions they try to improve by technical progress of their own, they were able to build the first power plants installed in Germany.

Siemens has concerned itself particularly with the pressurised light-water family. This firm has also undertaken the development of two designs of heavy-water reactor.

AEG constructs boiling-water reactors.

BBC-Krupp and *GHH-MAN* are concerned with high-temperature reactors; the former is developing the pebble-bed design and the latter is part of the *Inter Nuclear* group.

The utilities are privately owned and in general have not contributed towards reactor development.

The public authorities have encouraged, and thus made generally possible, the construction of nuclear power plants (*KRB*, *KWL* and *KWO*) and of test or prototype reactors *(MZFR, AVR, KKN, KNK)* by subsidising development and construction work and by underwriting any operating losses that may be made by the utilities.

In Italy, several industrial firms have entered the nuclear field. Three groups have now been formed:

– the first has been set up around the State holding company *EFIM* and is associated with *Fiat* through *Breda Elettromeccanica* under the agreement between *Fiat* and *Westinghouse* covering the construction of pressurised-water reactors;

– the second group was formed under the aegis of the *IRI* through its subsidiaries *(Progettazioni Meccaniche Nucleari Spa, Ansaldo Meccanico Nucleare Spa* and *Fabbricazioni Nucleari Spa)*, which are associated with *General Electric* (US) for the construction of boiling-water plants;

– the third group is centred on the State-owned corporation *ENI* with its subsidiaries *SNAM Progetti* and *Nuovo Pignone; SNAM Progetti* is engaged, in association notably with *TNPG* (British), on the construction of gas/graphite, advanced gas and high-temperature reactors.

Also noteworthy is the participation of *Montecatini* (co-founder of *Sorin* with *Fiat* and, with *Edison-Volta*, of *CISE*) in the construction of *ESSOR* and the design of the *ORGEL* prototype.

In Belgium, the firms concerned in nuclear development form part of the groups controlled by the large financial holding companies *(Société Générale de Belgique, Cofinindus-Brufina, Electrorail)*.

This applies in particular to *ACEC*, *Cockerill-Ougrée*, *BelgoNucléaire* and *MMN*. *ACEC*, *Cockerill-Ougrée* and *MMN* have formed an association with *Framatome* (France) and *Westinghouse* (US) for the construction of the Chooz 266 MWe pressurised-water plant.

BelgoNucléaire, which is currently setting up a design department, has until now devoted its main activities to fast reactors (it is taking part in the *SNR* prototype project) and the development of a medium-power spectral shift reactor (*Vulcain*).

This firm has also built up a capability in the manufacture of plutonium-based fuels and is part of the *Inter Nuclear* group.

In the Netherlands, the industry seems to have opted for a sub-contracting policy, at least where the market for proven-type reactors is concerned. It concluded special agreements with foreign companies for the construction of the Dodewaard plant. At the same time it aims at the market for major components and h as even succeeded in penetrating the American market.

The firm of *Neratoom*, which is made up of the nuclear interests of several powerful firms (*Philips*, *RDM*, *Stork*, etc.), is involved in the *SNR* prototype fast reactor project as part of a Belgian-German-Dutch industrial consortium.

Lastly, the firm of *KEMA* is developing a homogeneous suspension reactor based on the uranium-thorium cycle.

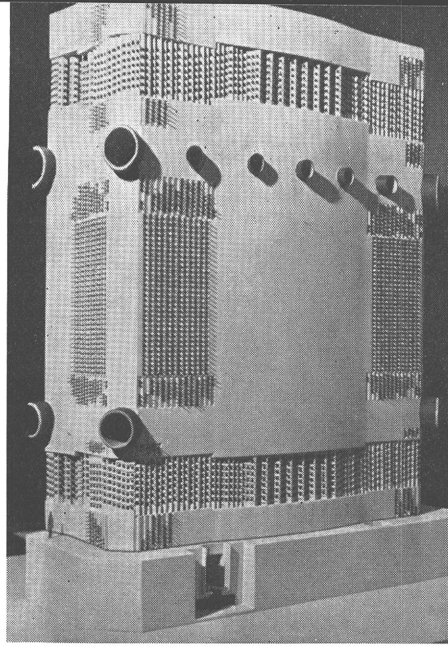
If the rôle of industry differs from country to country, the size of the firms, in terms of finance and production capacity, is also very variable (see Table I).

Apart from very large firms it seems that, on their own, the Community companies have difficulty in financing technological development programmes spreading over several generations of reactor families and in pursuing an aggressive sales policy, such as is practised by the American companies, in view of the financial risks involved in the construction and guaranteed operation of the high-power reactors demanded for reasons of competitiveness.

With regard to those major firms which have a broad enough financial base to roll with any punches, the fragmented nature of the market and the resultant poor prospects for orders have not in general encouraged them to invest on a large scale and to build up their nuclear divisions to a significant size.

Finally it must be noted that four of the firms (*Siemens*, *ACEC*, *Framatome* and *Fiat*) have links with *Westinghouse* and two (*AEG* and *Ansaldo*, with perhaps a third soon, *GAAA*) with *General Electric*, which is likely to restrict the action of each party concerned.

The last few years have seen certain



Model of the pressure vessel of the EDF 3 *gas-graphite power reactor.*

mergers in the nuclear industries. Thus:

— In West Germany the number of firms doing nuclear work is on the decline. There are moves towards co-operation and link-ups: co-operation between *BBC* and *Krupp* as *BBK*; merging of the reactor development departments of *GHH* and *MAN*; merging of reactor development work by *DEMAG* and *North American Aviation* and later *Babcock* and *Wilcox* under *Interatom*.

— In France mergers have produced two groups: *SOCIA* and *GAAA*.

There is also a trend, still confined to specific projects, towards co-operation between companies of different nationalities. The following may be mentioned:

— co-operation between the *CEA* and French reactor constructors, on the one hand, and *Siemens* on the other, with a view to developing heavy-water moderated, gas-cooled and heavy-water cooled reactors;

— co-operation between *GAAA*, *Interatom* and *Montecatini* on the *ORGEL* project;

— co-operation within *Inter Nuclear* by the firms of *BelgoNucléaire, GHH, SNAM-Progetti* and *TNPG* (and possibly *GAAA*, too) in drawing up the bid for a *Dragon*-type reactor;

— co-operation between *Siemens, Interatom, Belgo-Nucléaire* and *Neratoom* with a view to developing a sodium-cooled fast breeder reactor.

Praiseworthy as they are, however, these mergers and similar moves do not appear adequate to meet the demands of the market and allow the nuclear industry to develop in the Community, for the following reasons:

1) As has been stated already, nuclear energy only becomes competitive at high ratings. As a result, the number of reactors to be built is limited and the constructors must have a very sound financial and technical base in view of the risks involved in the construction and operation of such plants.

2) Each national market is too small for research and development costs to be amortised over a sufficient number of orders. Only the sale of a large number of plants (five to ten units, according to Mr. W. E. Johnson, a member of the *US Atomic Energy Commission*) can provide industries with sufficient business to recoup this cost, reduce prices and make nuclear plants competitive with conventional ones. Such a volume of orders could only be obtained on a national basis at best over a very long period of time and within a protected economy.

Furthermore, if each industry were to remain confined to its home market it would have to continue largely to rely on a licence system imposed by powerful foreign companies.* While certain licencees have gradually achieved greater independence with respect to their American partners, none the less the licensee generally lags behind its partner and has no opportunity, at least in the first few years, to profit by the particularly good openings in the market. Moreover, the licenser usually endeavours to limit the selling area for the products built under licence and thus prevent the creation of a large market for them.

However, multinational co-operation or mergers are essential to the creation of a genuine nuclear common market. The member countries admittedly abolished all custom duties on imports and exports, or taxes with equivalent effect, and all quantitative restrictions on both imports and exports in respect of nuclear products back in 1959, but in view of the preponderant influence wielded by the public authorities in the nuclear industry field, the abolition of customs duties and quantitative restrictions was not enough to ensure the free circulation of goods within the Community in this particular market. This is because each country wishes its home industry to develop and to benefit from its spending on research and development.

Moreover, even the Community market is not large enough to warrant competition between a large number of firms and allow them to face up to international competition.

As for the international market, it can only be tackled on the basis of a large number of orders—this alone can enable competitive prices and impressive references to be quoted.

Lastly, the supply of fissionable materials from Community sources will be possible only at considerable cost and this would not be economically justified on a national scale.

The structure of the Community's nuclear industries is therefore characterised by:

— the large number of contending industries;

— the lack of a genuine industrial common market, in particular as regards orders, despite the abolition of internal customs duties and quantitative restrictions;

— the paucity of the companies' capital resources in relation to the amount of the guarantees required on the construction and operation of reactors;

— the virtual absence of trans-national integration between constructors of the same type of reactor and the same fuel elements;

— very tough competition from industries outside the Community.

* Here it may be remarked that it has not hitherto been possible to initiate co-operation between European holders of licences granted by the same American firm.

3. The involvement of the public authorities in the Community

The public authorities in the Community (both of the Member States and of Euratom) have played a major part in the development of nuclear electricity.

Their involvement has taken different forms, varying with the country. To these involvements in a purely national sphere, which are not co-ordinated, have been added those of Euratom. These latter include not only the awarding of research contracts or orders to private industry, on both the Community and national levels, but also projects of a more promotional nature:

— the Euratom/US Agreement for Co-operation of 8 November 1958, which included a power reactor programme involving three plants (*ENEL*/Garigliano, *SENA* and *KRB*);

— the granting of "joint enterprise" status (pursuant to Chapter V of the Euratom Treaty) to four nuclear power plants (*SENA*, *KRB*, *KWL* and *KWO*);

— the programme of participation in power reactors covering five plants (*ENEL* /Garigliano, Latina, *SENA*, *KRB* and *GKN*), for a total amount of $ 32 million.

In the critical first years of the development of nuclear energy, these three projects prompted the electricity utilities to build and operate large nuclear plants and thus provided orders for the Community's reactor constructors, often enabling them to enter this new field of production for the first time.

One not inconsiderable factor in the subsequent development of the nuclear industries has been the institution of a general scheme for the exchange of experience, linked with the three projects mentioned above, as a result of which it has been possible to benefit from the know-how acquired during the building and operation of these plants, thus obviating difficulties in the construction of further reactors of the same family.

An attempt is made below to analyse spending on promotion of the industry. The analysis deals with each family of reactors in turn, a distinction being made between funds allotted directly at national level and those channelled through Euratom.

The figures given, however, are subject to major reservations in view of the difficulty in separating the proportion of the funds devoted to industrial promotion from that allocated to basic research.

Proven reactors

1) *The gas/graphite family* (France, Italy and Euratom)

Of the Community countries, only France has spent very large sums on the implementation of its nuclear power plant programme. Although precise figures are not available, a reasonable estimate is that France has invested several hundreds of millions of $ in its development programme for this type of reactor.

The Commission's activity in the field of natural uranium gas/graphite reactors dates only from 1963 and covers a research and development programme of the order of $ 6 million and a $ 4 million contribution to the Latina plant (built in Italy to a British design), earmarked for the fabrication of the fuel elements on a Community basis.

2) *The light-water family* (all the Community countries and Euratom)

Euratom has contributed towards the development of light-water reactors in the Community in several ways:

i) by awarding research contracts

— as part of the Joint Programme under the Euratom/US Agreement. Since this came into force at the beginning of 1959, the Commission and the *USAEC* have devoted $ 28 million to research contracts placed in the Community and in the United States;

— as part of its own programme, to the amount of about $ 4 million;

ii) as part of the programme of participation in the *KRB*, *ENEL*/Garigliano, *SENA* and *GKN* power reactors. The European Community has made provision in this way for the expenditure of $ 28 million representing participation in:

— charges incurred by the contractor owing to the short-fall in energy production,

— the manufacturing cost of certain reactor parts;

iii) by granting four companies (*SENA*, *KRB*, *KWL* and *KWO*) joint enterprise status. In this way the Belgian and German companies which would not otherwise have been exempted from direct taxation, like the electricity producers of the other Member States, received tax concessions which are difficult to quantify but have been estimated in the case of the *KWO* plant at $ 5-8 million.

Over the first ten years of the existence of the *European Atomic Energy Community*, the Commission has spent a total of $ 60 million on the development of light water reactors. The Member States, particularly Germany, Belgium and the Netherlands, have allocated large sums to this sector under their national programmes. Although it is hard to obtain sufficiently accurate information, the data which is available shows that the spending at national level is much greater than the funds placed at the disposal of the Community.

Lastly, on the basis of the information available, it may be felt that the French and Italian Governments have put very little, if any, funds into this form of activity. It should be pointed out, however, that the *CEA* has developed a pressurised water reactor under its military programme.

Unproven reactors

1) *The heavy-water family*

Heavy water/gas (Germany and France)

Only France and Germany have taken an interest in this family, building the *EL*-4 reactor (financed by *CEA-EDF*) and the *KKN* reactor (financed by the German government through the *GfK*), investments being estimated at more than $ 130 million.

The fuel cans for this type of reactor have still to be developed, research having been unsuccessful up to now, so that for the time being no large-scale project can be contemplated.

ORGEL (Euratom)

Euratom has spent a very large amount of money on this family ($ 80 million, of which 16 million under the first five-year programme), to which must be added a major part of the cost of the work carried out at the Ispra Centre—estimated at about 60%. The results of the *ORGEL* competition for bids, which is now in progress, will enable a decision to be taken on the desirability of commencing construction of a prototype reactor.

Three firms in the Community have shown their interest in this reactor from an industrial standpoint by entering for the competition.

Heavy water/heavy water (Germany)

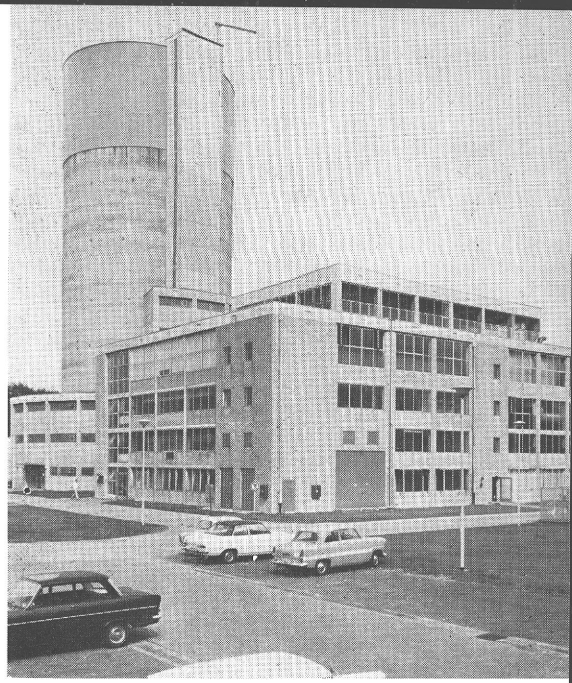
Only the German firm of *Siemens* has developed this family, building the *MZFR*, financed by the German government through the "*Gesellschaft für Kernforschung*" *(GfK)*, a company incorporated under private law. The investment expenditure on this reactor amounts to about $ 39 million. Its development led recently to a 318 MWe plant being exported to the Argentine.

Heavy water/light water (Italy and Euratom)

This type of reactor was first developed by the *CISE*, Italy (first under a Euratom contract alone and later under a Euratom-*CNEN* contract). The *CNEN* and *ENEL* have decided to build a 35 MWe prototype reactor *(CIRENE)* on which the development expenditure will be around $ 20 million.

Euratom's contribution to the implementation of this research programme has amounted to about $ 6.2 million.

The AVR *high-temperature reactor in Jülich (Germany).*



2) *The high-temperature gas family* (Germany and Euratom)

Under its *THTR* Association and the *Dragon* project Euratom has contributed a total amount of $ 45 million to the research and development budget.

The German government's contribution towards the cost of building the Jülich reactor *(AVR)* amounts to some $ 17 million out of a total of 25 million.

3) *Fast breeders* (all the Community countries and Euratom)

All the Community countries have an interest in the development of the fast breeder family. Up to the end of 1967 all the work was carried out under contracts of association with Euratom, which contributed $ 95 million towards the expenditure, accounting for about 35% of the total.

Have the results obtained justified the large appropriations of funds for such projects?

Only over the long term will it be possible to judge the profitability of the funds sunk in the development of reactors, so it cannot be estimated at present.

In connection with the preparation of the First Target Programme, the Commission made a calculation of the savings resulting from the gradual introduction of proven-type reactors, advanced converters and fast breeders in the Community's electricity grids in comparison with a generation programme not making use of nuclear energy. It emerged that, in the most unfavourable conditions for nuclear energy, the saving at present prices will top the $ 20,000 million mark by the end of the century and will therefore be much greater than the expenditure incurred in the development of these new techniques.

The fragmentary nature of these projects is inescapably obvious, since they have never formed part of a general policy in regard to reactor types. This explains the limited impact of Euratom's activities in the field of industrial promotion. France, for example, declined to draw on the funds budgeted for the programme of contracts of participation for the gas/graphite plants built within its borders.

Not all the paths opened by the Euratom/US Agreement for Co-operation could be explored, notably in the case of the power plant programme.

The joint enterprise concept has not been developed in all the ways foreseen by the authors of the Treaty.

National projects have not been co-ordinated with each other, leading to the design and development of a large number of reactor types using identical or different technology.

While it may appear technically justified and economically defensible for the Community to design and build several large prototypes of different families, in view of the relatively small cost involved in relation to the amounts already spent, it would be unwise from the economic and industrial angle to develop all the types to the industrial stage.

A choice must therefore be made forthwith and others will have to be made shortly.

4. Conclusions

The analysis carried out in the foregoing sections leads to the following conclusions:

a) Despite the small number of plants built or on order in Europe three types of "proven" reactor have been used in the Community, two under American licences.

With only one exception—the Chooz plant built by the *ACEC-Framatome-Westinghouse* group—these projects were completed and the calls for bids issued on a purely national basis. Thus some twelve firms (as opposed to four in the United States) have divided up the small European market between them (see Chapter II.2 above).

This dispersion is even more marked in the case of unproven reactors.

Finally, special fissionable materials have been obtainable only by ordering from countries outside the Community (United States or Britain).

b) The small number of orders placed with the Community's national industries has not encouraged them either to invest heavily or to join forces except by way of temporary link-ups.*

The industries of the Community, therefore, have often been content to build up fairly small staffs of engineers and research workers and to live in hope rather than adopt an aggressive approach.

These half-measures have in turn tended to strengthen the position of competing industries outside the Community and to diminish the likelihood of competitive reactors being produced.

c) Since the development of a given reactor family up to the commercial application stage demands an investment in terms of time and capital that is beyond the capability of the private sector, the public authorities have had to take over much of the financing necessary for the development of reactor technology (see Chapter II.3).

In the Community this considerable outlay by the public authorities has been made largely on a national basis and was in most cases devoted to developing families of identical or different technology. If this situation does not change, this will result in the market being fragmented for good and will lead to obvious duplication of effort and unnecessary competition, rendering the economic yield of the funds spent extremely questionable.

d) Only very large multinational firms or groups of firms will in the future be capable of meeting the utilities' requirements, which at the Community level are probably large.

The present situation is therefore a vicious circle, both for those states which have already spent considerable amounts and will have to incur major expenditure for many years to come in order to sustain the development of nuclear energy, and for the electricity producers, who have no guarantee of the satisfactory operation of their nuclear plants, as well as for the firms which, competing as they are in a small, badly organised market, cannot for lack of sufficient orders and prospects of orders spread investment and design expenditure over many years, hesitate to take risks and fight among themselves for subsidies.

Hence it does not appear possible for

* There has recently been an exception in the form of *Inter Nuclear.*

the Community to postpone any longer the industrial consummation of the very costly research policy that it has pursued hitherto. Having regard to the American lead, to delay any longer would deprive it of any prospect of success and would to a great extent nullify the benefits to be gained from the research effort.

Table I. Size of the main firms engaged in the nuclear field

Firm	Manpower (thousands)	Turnover in 1,000 million $
USA		
General Electric	375	7.74
Westinghouse	132	2.90
Gulf Oil	58.3	4.20
Combustion Engineering	29.8	0.69
Babcock & Wilcox	28.8	0.625
WEST GERMANY		
Siemens	242	1.98
AEG	135	1.29
BBC-Krupp	(123)	(1.54)
GHH	71.6	1.05
Interatom	32.0	0.36
FRANCE		
GAAA	(26.9)	(0.30)
SOCIA	(160)	(2.7)
BELGIUM		
ACEC (group)	14.9	0.23
BelgoNucléaire	0.3	not given
NETHERLANDS		
Neratoom	(288.9)	(2.76)
ITALY		
Fiat	146	1.91
ENI group	55.6	1.10
Montecatini-Edison	128	2.08
IRI	283	3.24

The figures between brackets relate to the parent companies having their registered office in Europe.

Table II. Appropriations made by the Member States (domestic programmes only), Britain and the United States to research as a whole and to the nuclear sector

	Total public expenditure on nuclear and non-nuclear R & D	Appropriations to nuclear R & D for peaceful purposes	
	(million $)	(million $)	% of total
Belgium	103	27	25.3
France	1,805	336	19.8
Italy	230	75	32.6
Luxembourg	—*	0.5	—
Netherlands	220	21	9.5
West Germany	1,200	187	15.5
Community	3,558	647	18.3
United Kingdom	1,450	131	9.0
United States	16,152	937	5.8

* This figure was not available.

Chapter III

ASPECTS OF RESEARCH ACTIVITY

1. The Community's research effort in the nuclear field

The avowed aim of the *European Atomic Energy Community* is to form a model of scientific and industrial co-operation in a pioneering sector and to contribute to the creation of the conditions necessary for the speedy establishment and growth of nuclear industries.

An analysis of the development of nuclear research in the Community shows that, in the light of the results, this aim has not been satisfactorily achieved.

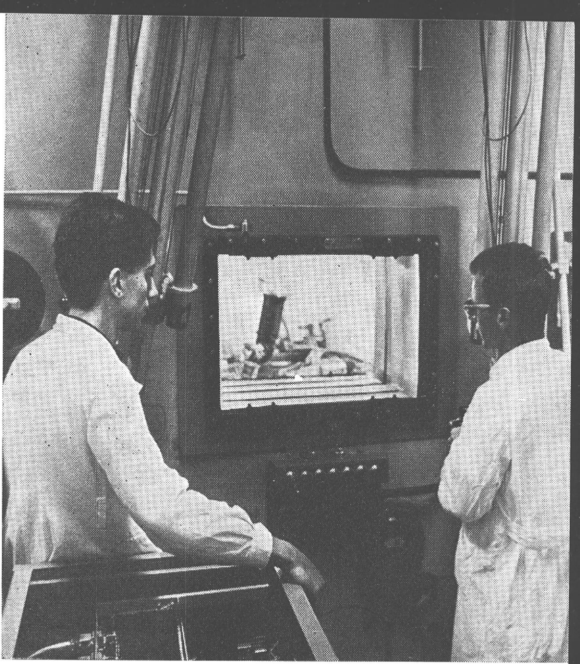
The Member States have devoted approximately $ 650 million to the financing of the first two Euratom five-year research programmes. From the table it can be seen that for the year 1967 alone the Member States spent an equivalent sum on the development of their domestic programmes. It is noteworthy that Euratom's annual budget remained virtually unchanged ($ 90 million) over the period 1963-67, whereas the funds made available for the Member States' own programmes increased considerably. Thus the appropriations for the Community research in 1967 represented only about 12% of the total nuclear spending of the six countries concerned. For guidance, the table below also gives the corresponding figures for Britain and the United States.

It may further be worthwhile to show the funds devoted by the Member States to Community nuclear research as a proportion of the total appropriations for all Community activities. Table III illustrates the relevant position for the year 1968.

From Tables II and III the following conclusions can be drawn:

a) The aggregate sums devoted by the Member States in 1967 to financing their respective national programmes—about $ 650 million —and their contribution to the international organisations *(CERN, ENEA, IAEA, Eurochemic)* and to Euratom —in all about $ 150 million —amounted to a total of roughly $ 800 million.

b) In absolute terms, the Community's total nuclear budget is equivalent to about 80% of that of the United States; in relative



Work in progress in a hot cell, Ispra Establishment of Joint Research Centre.

Table III. Resources made available by the Member States for all Community activities in 1968

Item	Amount million $	Contribution in %
— Communities operating' budget	107.2	5.3
— European Agricultural Guidance and Guarantee Fund	1,678	82.7
— European Social Fund	24.6	1.2
— European Development Fund	110.4	5.4
— Euratom research budget*	84	4.1
— ECSC research and reorganisation	26	1.3
Total	2,030.2	100

* Includes an amount of $ 41 million which, pending agreement on the research programme carried out under contracts of association, is being borne by the Member States.

value, it represents nearly 20% of the Community's total public expenditure on research and development, whereas in the United States the nuclear contribution amounts to only about 6%;

c) The Euratom budget accounts for less than 4% of the whole expenditure devoted to Community activities. It must be noted that the absence of an agreement on the financing of the research programmes covered by the contracts of association (indirect action)—not including the extension of the *Dragon* project—reduced Euratom's research budget for 1968 to roughly $ 43 million, thus bringing the latter's contribution down to about 2% of the total expenditure on Community activities (Table III).

It should further be noted that the Benelux countries' financial participation in the Joint Research Programme represents a far higher percentage of their overall research budget than that of the other Community countries. Consequently, the programmes of the smaller countries are more strongly influenced by the Community programme, without being more closely integrated.

The fact that the American nuclear research programme covers advanced sectors such as high-energy physics and modern biology with substantially greater resources than the Community's and includes such fields as nuclear propulsion for space devices and the use of nuclear explosives for peaceful purposes, which are not even touched upon in Europe, prompts the conclusion that, in certain sectors at any rate, the Community spends very large amounts, equal if not superior to the American figures. Yet, in spite of these efforts, nuclear development has still not reached a very advanced level of industrialisation in the Community.

Why, in the field of research, the setting up of a nuclear Community centred on the pooling of the member countries' efforts has not produced the accelerating effects expected of it is a question that calls for examination.

2. Euratom's action in the field of nuclear research

With regard to nuclear research, Euratom has a twofold duty, namely:

— to concert, co-ordinate and further research work undertaken in the Member States (Articles 5 and 6);

— to prepare and implement a Community programme (Article 4).

An analysis of the positive results and of the difficulties encountered by the Commission in carrying out these tasks is of major interest as a basis for preparing proposals for Euratom's future activities.

Co-ordination of research programmes

The experience acquired during Euratom's ten years of operation has shown that:

— the effort to confront and co-ordinate the national research programmes has so far had a limited effect in the technological sectors; on the other hand, it has been appreciated in certain fields concerning basic research or very long term objectives;

— in so far as a confrontation and co-ordination policy has been carried out in line with Article 5 of the Treaty, it has met with great difficulties.

Any action to dovetail research programmes must start with an inventory of the means available. Consequently, acting under Article 5 of the Treaty, the Commission started off in 1958 with a first overall census of the research projects under way both in the nuclear centres and in industrial and university laboratories.

The first stage of this survey enabled it to draw up a satisfactory balance-sheet of programmes. The follow-up action, however, intended to keep it up-to-date—and therefore efficacious—was unsuccessful. In order to close the gaps, co-ordination at the large-scale research level was sought within the Liaison Committees or Consultative Committees that head the Community programmes dealing with similar subjects and carried out under contracts of association (fusion, biology, fast reactors, high-temperature graphite/gas reactors, materials-testing reactors, etc.) and by the *Joint Research Centre* (chiefly heavy-water moderated reactors).

The results obtained were favourable and well received in the basic research sectors (e.g. fusion and biology), whereas they were far more fragmentary in the programmes dealing with technological development.

It was hoped that with the setting up, in 1961, of the Consultative Committee on Nuclear Research *(CCNR)*, that body would become the permanent organ for concerting the Community's research programmes. Although the different delegations have sometimes supplied information on the course of certain of their research programmes, it has never been possible to obtain genuine discussions in the *CCNR* at the preparatory rather than the completed stage of programmes.

Consequently, although it is true that the Community has been fully informed about the national programmes in which it took any part, it is equally true that hitherto it has not been afforded a full view of the whole of the research activities undertaken in the Member States. If this situation were to continue into the future, the

Commission would be without the essential means of carrying out the duty vested in it by the Treaty.

The very relative success of the measures to co-ordinate the research programmes largely accounts for the poor yield from research when it reaches the industrial stage, and this in spite of the considerable funds devoted to it.

The first thing needed today, then, is not so much to increase nuclear research and development spending in the Community as to rationalise it and set up procedures to bring about a better balance amongst the different sectors of advanced technology.

With this in view, the Commission considers it imperative to strengthen its programme-co-ordinating measures appreciably, not only through its own research activities but by resorting formally to the procedure laid down in Article 2 of the Treaty.

Rôle of the Community research programme

a) *Budget items*

As already stated, the total expenditure on the Community research and development programme over the period 1958-1967 amounts to some $ 650 million.

Table IV shows the breakdown of these appropriations amongst the principal activities under the different Community programmes.

The details set out in Table IV show that:

1) Roughly a quarter of the appropriations were devoted to investments and operation of the *JRC* establishments, whilst the remainder served to finance the various programmes carried out under research or association contracts.

2) Allowing for the fact that about half the *JRC* staff is engaged in research of a technological nature, the sum of the appropriations devoted to the reactor development programmes and allied sectors represents roughly 70% of the overall budget.

In addition, it should be noted that the amount spent on public service activities was low. These mainly concerned instruction, the dissemination of information, the *CBNM* programme, certain *CETIS* activities, and research on radiation protection.

b) *Euratom's direct action*

Direct research is entrusted to the *Joint Research Centre*, which has developed the *ORGEL* project amongst others. The *JRC* comprises four establishments in different parts of the Community* and has 2,250 employees.

The positive aspects of this action are backed up by a certain number of major achievements, which include:

— the technical quality of the numerous items of work carried out at the Ispra centre and, under the *ORGEL* project, the development of such complex units as the *ECO* critical assembly and the *ESSOR* specific test reactor, with the aid of numerous Community industries;

— the work of the Ispra computer centre *CETIS*, which is mainly of a public service nature, in the form of back-up work for the Joint Programme and for the other research programmes in the Community as a whole. *CETIS* has also devoted part of its efforts to improving the disciplines based on its activities;

— the quality of the work done by the *Central Bureau for Nuclear Measurements (CBNM)*, which enabled American-Anglo-Canadian co-operation on nuclear measurements to be expanded to include the *OECD* countries. Thenceforth the Anglo-Saxon and European programmes were and are closely integrated within the European-American Nuclear Data Committee;

— the efficient conducting of the irradiation programmes in the Hoge Flux Reactor (HFR) by the Petten establishment;

— the design and fabrication—within the specifications and the time limits—of the fuel for the *MASURCA* critical assembly by the *European Institute for Transuranium Elements*.

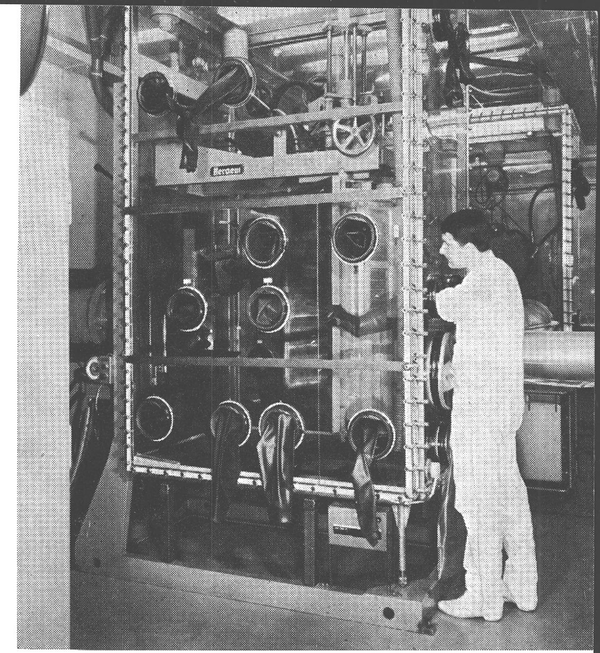
In contrast to these positive achievements, mention must be made of the extremely serious difficulties encountered by the Commission in the management of the *Joint Research Centre*. The worst is the curbing of the *JRC*'s growth, decided upon

* Ispra establishment, Italy: 1,610 personnel;
European *Institute for Transuranium Elements* at Karlsruhe, Germany: 223 personnel; Petten establishment, Netherlands: 211 personnel;
Central Bureau for Nuclear Measurements at Geel, Belgium: 175 personnel.

Table IV. Total appropriations under Community research budgets in the period 1958-1967, itemised according to main activities

Subject	Amount (million $)	% of total
Direct action		
Investments and operation of the four *JRC* establishments	175.8	27.0
Indirect action		
— proven-type reactors	69	10.6
light-water reactors ($ 60 million)		
nat. uranium graphite-gas reactors ($ 9 million)		
— heavy-water-moderated reactors	124.4	19.1
organic liquid coolant		
(*ORGEL* project + work conducted at Ispra $ 118 million)		
boiling light water coolant		
(CIRENE) ($ 6.4 million)		
— suspension reactor *(SUSPOP)*	4.3	0.8
— high-temperature graphite-gas reactors	45.3	7.0
Dragon ($ 34.4 million)		
THTR ($ 10.9 million)		
— fast reactors	96.1	14.8
— marine propulsion	12.1	1.8
— related sectors (irradiated fuel reprocessing, waste processing and disposal)	10.0	1.6
— controlled thermonuclear fusion	45.4	6.9
— biology	19.6	3.1
— instruction and additional training	4.0	0.6
— dissemination of information	10.9	1.7
— operation of materials-testing reactors (*BR*-2 and *HFR*)	28.4	4.4
— radioisotopes	4.8	0.7
Total	650.1	100

View of a vacuum-type induction furnace at the European Institute for Transuranium Elements, *Karlsruhe.*



by the Council during the second five-year period, which brought the personnel ceiling substantially below the figure originally planned. The result has been that certain of the *Joint Research Centre's* facilities are not being used to capacity. The resultant situation bears unfairly on the staff and is ultimately prejudicial to the Community which provided these funds.

c) *Euratom's indirect action*

This relates essentially to the research programmes carried out under contract or association arrangements.

The contracts and associations entered into by Euratom have mainly had the following objectives in view:

— to co-ordinate the studies relating to proven-type reactors and nuclear marine propulsion systems;

— to unite into an orderly European scheme the various research projects on:
fast reactors,
controlled thermonuclear reactions,
nuclear biology and its applications;

— to support certain European initiatives such as pebble-bed reactors *(AVR)* and suspension reactors *(KSTR)*;

— to promote collective enterprises that extend outside the Community (Halden and *Dragon* reactor projects);

— to call upon the competent public or private bodies of the Member States to assist in the *JRC*'s own work, more especially on the *ORGEL* programme.

Similarly, the Commission's management of these programmes has been generally appreciated. The integration of all the research programmes carried out in the Community in the field of controlled thermonuclear fusion, and likewise the tight co-ordination of a number of nuclear biology programmes, are typical examples of fruitful Community co-operation. In the same manner, the contracts concerning technological domains have helped to establish a number of more or less stable links between different industries.

Nevertheless, apart from the technical results proper, these activities have had only a fragmentary sequel inasmuch as they could not be built into an overall strategy for the development of an industry integrated at Community level. Far from it, for under the pressure of the Member States, technical success was unable to prevent (or even induced) an increasing pursuit of individual interests. This is especially true in the essential sector of fast reactors, where association agreements were unable to check the crystallisation of research, carried out chiefly in France and Germany, around two independent prototype reactor projects, entailing the duplication of large-scale equipment including the *MASURCA* and *SNEAK* critical assemblies, the high-power sodium loops, etc.

As for the *Orgel* project, it has so far not been able to take its place in a consistent development policy for heavy-water-moderated reactors, and yet the Community has devoted very large appropriations to it. This situation is mainly due to the fact that several Member States have engaged upon the development of various heavy-water-moderated reactor versions outside the dovetailing action that the Commission had proposed by setting up, back in 1959, an *ad hoc* working party.

d) *Dissemination of information*

As part of the duties vested in it by the Treaty, the Commission established a policy for the dissemination of information and the protection of industrial property rights.

To provide for the circulation of the scientific results given in publications and reports, the Commission in 1959 set up the *Centre for Information and Documentation (CID)*.

Alongside this work, the *CID* undertook the development of a semi-automatic documentation system, and placed it at the disposal of interested parties.

This system, whose value has been recognised, can be extended to other scientific and technical fields.

Table V gives an idea, through the number of reports, communications and patents filed, of the Community's activity as regards research.

3. Problems raised by the research carried out so far by Euratom

As has been pointed out above, the inadequate co-ordination of all the research activities within the Community has introduced disruptive influences into the Joint Research Programme, particularly in the field of indirect action. These difficulties, which date from the first revision of the second five-year research programme in 1964, underlie the situation currently paralysing the activities of Euratom.

The principal factors responsible for this situation are the following:

Restrictive application of the "fair return" concept

Perhaps it is inevitable that every member of an organisation such as the *European Atomic Energy Community* is tempted to secure

Table V

	Publications*	Communications**	First filings of patents	Document retrievals***
1958-1963	325	596	354	416
1964	888	321	149	267
1965	1,012	332	207	222
1966	1,336	297	194	418
1967	1,396	402	171	1,154
1968 (1st half)	1,096	202	79	409
Total	6,053	2,150	1,154	2,886

* The term "publications" covers scientific and technical articles in periodicals conferencepapers, oral exposés, and "EUR" external reports; the *Joint Research Centre's* internal reports, which number roughly 1,500, are not included in these figures.

** Communications concern non-published information; they are issued to the Member States and to persons and enterprises which can provide proof of a legitimate interest.

*** The *CID* semi-automatic documentation system went into service towards the end of 1966, which accounts for the very sharp rise shown by the figures from that date onwards.

the maximum return for his contribution and make certain above all that the dividends accruing to him from his participation are greater than those which he could have anticipated from investment of the same capital in a scheme of a purely domestic nature. But the first difficulty is that of accurately assessing the profit obtained. According to a very over-simplified concept, a balance has to be struck between the financial contribution to the Community budget and the corresponding expenditure made by the Community in the country in question. Yet this line of reasoning overlooks a number of aspects, among which might be cited the cumulative benefits which follow from being better informed on the research in progress and the working methods in use in the various Community laboratories, and again, the benefits derived from the development of scientific information and know-how acquired by the personnel engaged in Community tasks.

It is none the less true that the value of research making a rapid impact on industry depends far more on the participation of specialised bodies and industries in research into and the construction of equipment than on the dissemination of information. Know-how is the essence of the acquisition of knowledge which can be used by industry and can only be obtained through direct participation. The problem which arises for the third Community programme is to take due account of past experience and do away with the "fair return" in its unacceptable form of merely passing through the Community budget sums which in actual practice go towards the financing of unco-ordinated national programmes.

The solution to this problem must be found in overall compensations striking a balance between the financial contributions of the Member States and a rational apportionment of the tasks to be performed. This balance would be more easily attained if it were no longer applied to nuclear research alone but extended to other sectors of advanced technology.

Policy on research contracts

In this field as well, a frank and open discussion of all the various "fair return" concepts would have certainly led to greater efficiency.

To begin with, it might in certain cases appear justifiable to have adopted the principle of having research financed entirely by the Community in order to speed up the formation of a vast scientific and industrial research capability, but as this potential gradually develops it is reasonable to adopt the concept of a sharing of the expenses between the Community and the contracting party, in view of the profit which the latter can expect to derive from the increase in his resources and know-how.

Another difficulty derives from the fact that research contracts are frequently considered as simply a matter of acquiring results in return for payment. In fact, the value of a research project is not solely confined to obtaining results, but it also lies—and sometimes more so—in the know-how which is acquired in the course of it. Consequently, in order to ensure that the Community derives genuine benefit from its research contracts, it is essential for members of its own staff and even workers seconded from other firms to be able tc participate in the research in close collaboration with the contractor's personnel. However, while the restrictions imposed on the size of its own staff has prevented the Commission from assigning Community staff to the majority of the contracts, industry has also shown itself to be reluctant both to second its own employees to the Community and to accept workers from other firms.

Rôle of contracts of association and participation

The idea behind this rather specialised form of collaboration is to place certain big national projects on a Community footing and to avoid useless duplication of effort when such projects are under way concurrently in several countries. In order for the Community to have any real say in the orientation of the programmes, it would appear essential for it to provide a substantial contribution in terms of manpower and funds.

The financial contribution has gradually decreased to the point where it is virtually non-existent in the majority of cases, despite the creation of equal-representation committees. But what is more serious still is that participation in terms of manpower has likewise dwindled.

It has sometimes been claimed that the association form of contract was not effective. This is not true for long-term research, for no-one could conceivably challenge the correctness of the formula with regard to fusion or biology, except in those instances where the Community has not been able to delegate staff to an extent commensurate with its financial contribution.

The formula of contracts of participation has only been used in fact for the power plants to which the Community has granted financial aid, receiving in return access to the information derived from these projects.

Here again, the value to the Community would have been much greater if both the manufacturers and the Community had used more staff, for the real advantage of operations of this sort lies in the creation of a specialised staff which has acquired thorough knowledge based on the inevitable daily incidents. In spite of this, contracts of participation helped industry at the time the first nuclear power plants were put up.

Relative importance of guided or non-guided research in Community programmes

By virtue of the tendency towards austerity to be discerned in the research budgets of the Member States, it has been recommended in certain quarters that the emphasis should be placed more on research directly relevant to the development of industrial applications which are commercially feasible over the short or medium term (guided research), though this might mean staggering other projects. It should nevertheless not be forgotten that the most fundamental research is the natural source of future developments and applications and that an abandonment or appreciable slackening in the pace of basic research would result in accentuating Western Europe's scientific and technical lag, and would encourage the brain-drain, which has been one of the major causes of this lag.

In the nuclear sector, research and development is pursued, to a large degree at least, in centres having important installations and teams of researchers in widely differing disciplines.

Table VI shows the personnel figures for the main Community research centres.

The total body of researchers attached to these different nuclear centres constitutes in itself a considerable asset. From an analysis of the overall breakdown of the personnel of the national centres and that of the *Joint Research Centre*, according to whether the research is guided or not, the following main conclusions can be drawn:

Experiment in progress in a laboratory of the Biology Department, Ispra Establishment of Joint Research Centre.

Table VI. Staff of main research centres in the Community

Centre	Approximate overall personnel figure
Belgium	
CEN	1,100
France	
Saclay, Fontenay-aux-Roses	7,000
Grenoble	1,300
Cadarache	1,500
Italy	
Casaccia	1,200
Bologna, Saluggia	300
Netherlands	
RCN	800
West Germany	
GfK	3,200
KFA (Jülich)	3,200
Munich	1,200
Total (1)	20,800
Community	
Ispra	1,640
Karlsruhe	223
Geel	175
Petten	211
Total (2)	2,249
Total (1) + (2)	23,000

– contrary to what is generally accepted, the programmes of the *Joint Research Centre* are aimed to a greater extent than those of the national centres at specific technological targets;

– the number of researchers in national centres assigned to studies within loosely-defined limits—but whose intrinsic value and interest are not disputed here—is very large.

At the numerous discussions held between the organs of the Council and the Commission on the establishment of the programme of Euratom's future activities, certain Member States expressed their eager wish for an integration of research on the basis of well-defined objectives and the elimination of overlapping.

The foregoing conclusions show that the problem is a general one and is more acute in the national centres than in the *Joint Research Centre* establishments. And this situation is rendered worse by the fact that much of the non-guided research does not fall within even a general framework. This leads to fragmented studies involving many duplications and a good deal of "re-invention".

All this points, then, to the need for co-operation between national and Community authorities with the aim of obtaining, under a comprehensive nuclear policy, proper apportionment of the research among the existing facilities and, by progressive reorganisation of the nuclear centres, setting in motion the expansion and technological diversification which are so necessary to the Community.

4. Conclusions

The progressive shifting of nuclear research to the industrial plane necessitates a reorganisation of research methods (technological and others) so as to focus on objectives geared to a unified energy policy and paying due heed to the basic requirements of a Community industrial policy.

The lack of effective permanent harmonisation between the Member States and the Commission has prevented this vital objective from being reached with the maximum advantages for the overall economy of the Community as well as the people concerned.

It has become clear that the rôle of the nuclear centres is all the more important as in general they have the large-scale equipment which is vital for technological tests. The optimum benefit to be derived from these facilities necessitates a fair apportionment of the various tasks among the different Community centres on the one hand, and close co-operation between these centres and industry on the other, as well as a reorganisation of the sector concerned.

An analysis of past experience shows that such a policy would increase the efficiency of the research effort not only by the savings which it would bring about in the immediate future, but also by lowering the time-lag between invention and industrial application.

Finally, all the difficulties set out above and in Chapter II have resulted in inadequate use of the combined research potential, and consequently a wastage of resources. The term "combined research potential" should be construed in its widest possible sense. It includes not only the equipment and research personnel of the *Joint Research Centre* but also, albeit in a very general way, the facilities for intra-Community co-operation in research and development, which have so far been largely untapped.

Part II
General Aims and Proposals

The critical analysis in Part I shows that what is being done by the Community institutions is calculated to enable the Community economy to reap a more substantial reward from the researches undertaken and the scientific and technical successes obtained.

It is evident that in order to be effective and useful, any project in the nuclear field must fit into a Community-level framework of decisions or, at the very least, sufficiently specific guidelines concerning:

- determination of the market prospects facing the Community's nuclear industries;
- encouragement of these industries to combine their forces in multinational companies;
- the mapping-out of a genuine reactor strategy in line with technical, economic and political factors: comparative profitability prospects, nuclear fuel supply arrangements, possibilities of industrial reorganisation, etc.;
- the co-ordination of nuclear research and development programmes with a view to more balanced apportionment and better use of public funds.

In the Commission's view, four types of action are of immediate importance; they are dealt within the four chapters of Part II and relate to:

- industrial promotion of reactors on a Community-wide scale;
- combining of national and Community research and development efforts in the reactor field;
- uniting of efforts as regards supply arrangements;
- co-ordination in nuclear research and allied fields.

Chapter I

INDUSTRIAL PROMOTION OF REACTORS ON A COMMUNITY-WIDE SCALE

Past experience and the present situation show that no further time must be lost in setting the industrial targets, preparing and selecting alternatives, and putting the right machinery in motion to carry them out. This policy could develop along the following lines, certain of which can only be laid down in detail after wide-ranging consultations with experts from the Member States and with the sectors concerned.

1. Target Programme

In view of the promise offered by nuclear power as a new, cheap, stable source of energy, care must be taken to ensure that it takes its place among other energy sources under the best possible conditions.

At present there is not enough information on the trend of the Community nuclear power plant market, a lack which prevents industrialists from developing a strategy for their investments and a commercial policy.

Consequently, the Commission considers it necessary to draw up, with the assistance of the electricity producers, an assessment of the future development of electricity generation for the whole Community. This assessment should not be simply a list of the six Member States' respective forecasts or programmes, but should afford better use in the Community of the various sources of energy for electricity production.

When this overall assessment of electricity generation in the years ahead has been finalised, the Commission will have to prepare, with the assistance of all the interested parties (electricity producers, industrial sectors, various bodies) multiannual target programmes, to be reviewed regularly, specifying nuclear power's contribution to electricity output. This need is particularly real because the development of nuclear power for electricity generation demands a reactor strategy and concerted fuel management in tune with the technical and economic facts of life.

The influence of these target programmes on the nuclear power plant installation programme and on the Community's entire nuclear industry will only be really effective if all the Member States and all the partners concerned are firmly convinced that the road to success must of necessity be sought in co-ordinated action at the Community level.

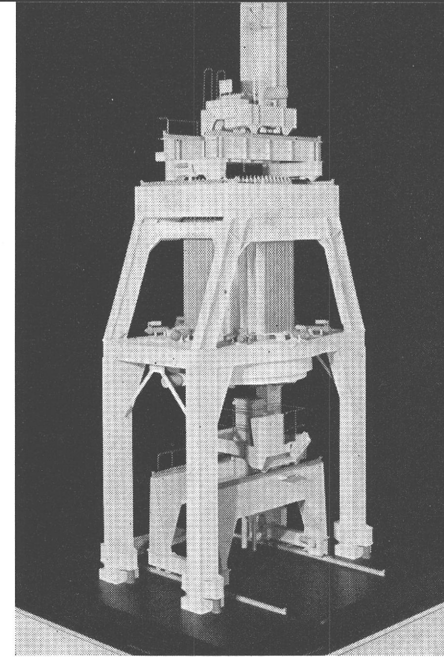
2. Establishment of a common market for nuclear power plants

The target programme must enable an estimate to be made of the nuclear power plant capacity that would be ordered in the Community. This medium-term estimate should be backed up with a statement by the electricity producers on their decisions regarding the power plants of all types that they have decided to order. At the start of each year, the nuclear power plant construction projects would be examined by the Community authorities in consultation with the principal parties.

This annual scrutiny of orders for power plants should make it easier to standardise the types, sizes and equipment used in the projects, a step which is urgently needed to enable the Community's industry to execute orders under more profitable conditions; it would be a valuable aid to industrialists in their technical design studies and would substantially reduce the expenses incurred by them in preparing tenders.

At the present time, the diversity of industrial standards, especially for structural materials, seriously impedes the realisation of a nuclear common market. Some progress has been made, and the rest must now be accomplished rapidly. Once the technical components are standardised, tenders should wherever possible be invited for the relevant projects and should be open to the whole of the Community industry. Thus the legal situation created by the nuclear common market would become a *de facto* situation.

If the Community enterprises are to increase their strength, to combine in multinational consortia and to develop a commercial strategy, they must be able to



Model of the SNEAK *fast neutron critical facility, Karlsruhe (Germany).*

count on a certain number of large-scale orders. It would probably be a useful step, therefore, if the responsible public authorities and/or the electricity producers were to pool all or part of their orders for the year, by groups of two to four power plants, as is now done in the United States. With the orders combined in this way, the manufacturers would be able to make their tender prices considerably lower and still be sure of a sufficient turnover to offset their investment and research expenditure.

3. Technical aid to nuclear power plant operators

The pooling of experience, organised jointly by the Commission and the electricity producers, has enabled power reactor operators to cut out recurrences of technical obstacles and to co-ordinate their efforts to solve the technological problems inherent in the operation of power plants.

This co-operation has yielded such good results that it is considered advisable to continue and expand such technical aid to operators.

Recent experience has shown the need for specific action to improve operating conditions so as to meet the producers' requirements.

4. Aid to the nuclear industry

As nuclear activities in the various Member States lead on progressively to industrial developments, whether it be in the erection of power plants in or outside the Community, it becomes more imperative to put into effect the general principles underlying the European Community. This applies particularly to assistance in the marketing and export of nuclear power plants, which hitherto has usually been granted on a national basis.

It would in any case be essential to co-ordinate the various countries' aid systems within the Community. It may reasonably be asked, however, whether it would not be advisable to go further and set up a Community aid system which would partly replace the national measures and might take the form of a European Nuclear Industry Development Fund. The object of the Fund would be to promote the conditions under which European nuclear power could come into its own. It would aim at improving the efficiency of known or promising techniques and the transition from public to private financing. It would be a means of boosting and guiding industrial activity, and in particular could:

—provide the financial security needed to cover certain exceptional technological risks still inherent in the nuclear field, which European constructors, owing to the limited scale of their finances, are scarcely in a position to bear;

—assist in the construction of power prototypes by helping to relieve the financial burdens involved;

—contribute to any other major industrial project in the nuclear sector (e.g. uranium enrichment plant, heavy-water production plant).

Another form of aid to enterprises which has already been employed is the granting of joint enterprise status. To what extent better use could be made of the advantages conferred by that status is a question which ought to be examined. Joint enterprise status and enjoyment of the Fund should be reserved for projects in respect of which an invitation for Community tenders is issued, or which at least form part of a common policy for development of the nuclear industry.

The effort asked of the public authorities and utilities as regards forecasting and concerting their orders, and the financial support that would come from the State or Community authorities, should be matched by an effort to reorganise the Community's industry. For, fragmented as it is, it mostly has to rely on government subsidies, which accounts in no small degree for the fencing-off by each country of its own market. This is why the series of measures described above should be accompanied by a movement towards integration in the industry on the part of both the designers and the manufacturers of reactors or components. By combining, the industries would be able to strengthen their technical and financial basis and so to take certain risks, at the same time offering better price conditions, and this would certainly serve to widen the outlets for nuclear power plants both inside the Community and on export markets.

While such combinations must be encouraged, in principle it is not desirable for them to be effected on a mainly national basis. Complementarity in all branches of the industries in question cannot necessarily be found inside any one country. Industries should bear this in mind when seeking, in the Community as a whole, the most suitable partners for a profitable combination.

The governments and the Community institutions ought to encourage this trend by giving it their explicit approval and removing the obstacles of all kinds still present today.

A movement on these lines would open up the way for the formation of a number of industrial consortia capable of meeting international competition and tendering under the best technical conditions, irrespective of nationality, for nuclear power plants in the Community. In order to stimulate the formation of such groups, the Community, for its part, ought wherever possible to give priority to the multinational groups thus established as regards grants from the development fund.

Chapter II

CO-ORDINATION FOR COMBINING THE NATIONAL AND COMMUNITY EFFORTS IN REACTOR RESEARCH AND DEVELOPMENT

As was shown in Part I, the current situation of reactor research and development in the Community features a multiplicity of projects, mostly being conducted or planned on a national basis. The unco-ordinated pursuit of all these projects up to the stage of commercial manufacture would inevitably result in exorbitant expenditure and the marketing of too many types of power plant for the available outlets.

An immediate start must thus be made

on opening up the way for a concentration of effort by selecting, in common, a certain number of projects. The lack of such selection in the past has detracted from the efficacity of research and from the growth of a Community industry.

It is difficult to carry out such a selection process at the present time. Generally speaking, the technological data available are often shaky, until confirmed or corrected by the building of a prototype, and in certain cases the selection or rejection of this or that project is virtually a shot in the dark. These decisions ought to be based more especially on the answer to two questions: what importance is to be assigned to dependability of supply, and what place will breeders occupy?

Even so, whatever efforts are undertaken need to be co-ordinated and smoothly meshed. In other words:

—it is advisable simply to pursue the development of the most promising variants and to build prototypes only within the context of development programmes based on the potential and requirements of the Community as a whole;

—programmes concerned with basic research on and development of components should be integrated and harmonised at Community level;

—the close collaboration of the Member States' industries on the construction of prototypes and components which would be afforded by concerted utilisation of official appropriations must be so planned that it will also warrant collaboration in the series manufacture of the reactor family evolved from these prototypes.

Within the specific context of the Euratom Treaty, it is possible, by making use of the provisions concerning joint enterprises, to pursue common aims through the concerted action of national and Community public bodies and possibly of the industries concerned. From the financial standpoint, the relevant provisions permit of all possible apportionments amongst the participants, thus facilitating the pursuit of certain aims by six countries jointly.

By means of appropriate regulations laid down for the management of the joint enterprise, unity of action can be achieved while at the same time ensuring the necessary degree of autonomy for the individual programmes of the participating bodies.

This formula appears to allay most of the anxieties expressed in the Council's resolution of 8 December 1967 as to the forms of collaboration for researches that lead in the short term to industrial production, even when it is not possible for all the Member States to participate. Other research schemes could be the subject of complementary programmes, without necessarily using the joint enterprise formula.

In fact, any complementary programme, whether or not in the form of a joint enterprise, must be tied in to the common programme, and for this purpose it must fulfil two basic conditions:

—effective participation of the Commission;

—the guarantee of the widest possible dissemination of information, with due allowance for the restrictions imposed by respect for industrial property rights.

The fact remains, however, that the risk of fragmentation would not be eliminated by recourse to these formulas unless they were backed up by a common programme substantial enough to counteract the centrifugal forces.

1. Proven-type reactors

A research and development effort is still needed in the case of proven-type reactors, so as to achieve greater reliability, lower prices and gradual release from the shackles of external licences and processes. These technological researches are the industrialists' business; nevertheless, the Community's research centres can give such work useful support. Efficient circulation of the research findings amongst industrialists is still a major factor in the improvement of reactor technology in Europe. In addition, co-operation between industrialists to develop the principal components could be the first step towards subsequent integration.

2. Breeder reactors

Among the unproven types of reactor, the fast breeders are particularly promising. There is a consensus that the magnitude of the technological questions to be solved and the extent of the outlay required call for the immediate introduction in the Community of measures to co-ordinate and concentrate the programmes now going forward in the six member countries at both research and prototype level. Otherwise it would become impossible to attain the true objective of these programmes, which is to endow the Community with a strong industry free of all non-Community apron-strings and capable of submitting competitive tenders for fast breeder power plants with a capacity of some 1,000 MWe. Furthermore, development must be geared to readiness for the commercial emergence of fast reactors towards 1980-1985, if the Community hopes to compete with the developments now going ahead in other parts of the world, particularly in Britain, the United States, the Soviet Union and Japan.

If the present situation (see Part I, Chapter II, 1.), characterised by the unco-ordinated development of three projects, should continue, it will be disastrous for the future of the Community's industry in this sector. Such fragmentation entails longer, more expensive research and may well cost Community constructors a place in the world market.

Hence the Community's aim for this type of reactor must be to arrive as quickly as possible at the first in a series, which would be a pre-commercial 600-1,000 MWe reactor. All roads to this objective are acceptable to the Commission provided that they really lead there, the joint enterprise being in this case the best vehicle. The characteristics of such an enterprise should be:

—unity of technical conception;

—dovetailing of research efforts carried out in the Community;

—grouping together of the Community enterprises that desire to join in the project.

This enterprise should enjoy the benefit of:

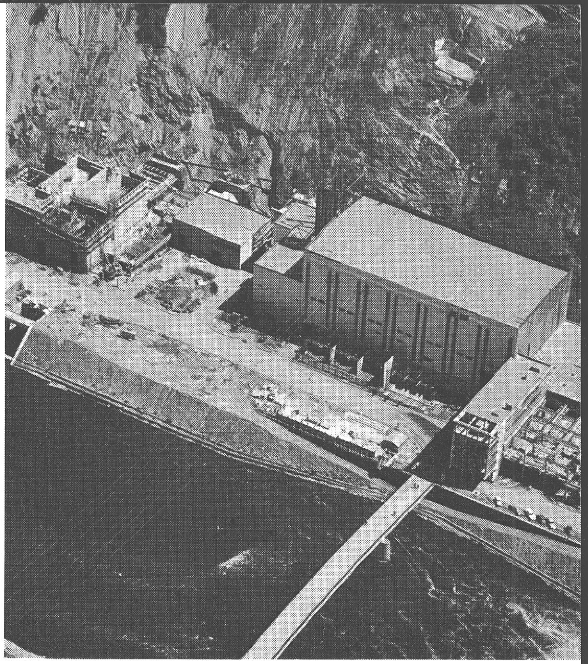
—the most important results from the two 250 MWe prototypes, with due regard for industrial property rights;

—the work and tools developed previously under contracts of association between the various Member States and Euratom;

—the joint use of all the test facilities already existing or the construction of which has been decided on;

—the design, development and utilisation

Aerial view of the Franco-Belgian power plant at *Chooz in the Ardennes* (SENA).



of any new test device or improved version of an existing device.

If the Council failed to reach unanimous agreement on the principle of a joint first of a series and if the conditions set out above were not all met, then the formation of one or more joint enterprises would not make it possible to attain the industrial policy aims that the Commission deems essential.

The negotiating of such a joint enterprise will necessarily take time. Pending completion of this process, the Commission cannot ask straight away for all the funds needed for its participation to be included in the programme.

An immediate solution consists in:

—maintaining and strengthening the co-ordinating links between the different projects;

—requesting merely the funds required to keep the specialised team together and to ensure direct action for 1969.

This is without prejudice to subsequent financial and technical participation by the Community in such a course of action.

3. Advanced converter reactors

Where advanced converters are concerned, it is impossible to choose immediately from among the different systems. The choice cannot be deferred for very long, however, because the cost of developing all the envisaged systems or variants up to the marketing stage would be prohibitive and would delay fruition of the Community efforts in a field where progress is equally rapid in non-Member States. Whilst the situation is relatively satisfactory with regard to the high-temperature type, where the differences only concern certain aspects connected with the reactor design, it is a different matter with the heavy-water systems.

Here, as elsewhere, the Community's limited means oblige it to concentrate its efforts, which should ultimately lead to an industrial grouping in the high-temperature field, in which the aim is, as for heavy-water reactors, to push forward a single basic type.

a) High-temperature gas-cooled reactors

The European origin of this type of reactor, the favourable technical and economic prospects, and the good use it affords of fuel reserves warrant a united effort by the whole Community to carry out, as quickly as possible, all the work still needed to bring this system to complete maturity. This stage will be fully attained with the development of reactors capable of operating at temperatures high enough for the traditional steam cycle to be replaced by the new direct cycle with gas turbines operating in closed circuit in power plants of the order of 1,000 MWe. It must be pointed out, however, that the operating of these reactors implies guaranteed access to a source of enriched uranium.

The Community has participated in the development of the two high-temperature gas reactor variants that have been studied in Europe, both of which have reached the stage where the construction of power plants of several hundred megawatts can be envisaged. Most of the necessary technical developments are common to both variants.

On 22 May 1968, the German government requested the Member States to set up a co-operation arrangement to bring the high-temperature reactor system to full maturity.

The setting-up of a European co-operation arrangement to deal with the whole of the research to be developed for this system is a fundamental aim. These researches should be co-ordinated and managed under a joint basic programme combining the different measures taken or to be taken in the Community countries to improve the performances of steam-cycle power reactors and to develop the direct gas-turbine cycle.

Here too, the Commission regards all routes to this target as suitable provided that they really lead there, the joint enterprise being one possible way of achieving the goal. Such an enterprise should have the same characteristics as those specified above, in Chapter II.2, for fast breeders.

As early as 1969, a certain proportion of the *JRC* potential could be used for basic and back-up research of common interest to both the high-temperature gas reactor variants. In order to further the implementation of the various activities planned in the Community and to enable the Community industrialists to retain access to the *Dragon* reactor, under similar conditions to those afforded their opposite numbers in the United Kingdom, the Commission considers it is important to extend the *Dragon* Agreement beyond March 1970.

b) Heavy-water reactors

The interest of these reactors, whose industrial prospects have not yet been fully explored, lies mainly in the fact that they can be operated with natural or low-enrichment uranium, which offers unquestionable advantages as regards supply arrangements and the export prospects which hinge on them. One is bound to ask whether these reasons would not justify, from considerations of overall strategy, the development up to a fully industrial stage of the most promising system and the setting-up of an appropriate heavy-water production capacity. The decision to build an enrichment plant in the Community might alter the data underlying this problem.

In the immediate future, however, it is very difficult to make a selection, based on objective data, from among the unduly large number of programmes being pursued in the Community.

The aim, therefore, must be to prepare the ground for a selection by carrying out a thorough-going joint review of the problems raised by these different systems, with particular regard to the tender that a group of Community industrialists has undertaken to submit at the end of 1968 for the possible construction of an ORGEL prototype.

The *Joint Research Centre* possesses a body of skills and installations, and notably the *ESSOR* and *ECO* reactors, which will enable it to contribute decisively to the development of the various projects.

4. Exploitation of research results

The Community must continue to take the utmost care to ensure that research findings are efficiently passed on to the industry.

Up to now, the Commission has had to confine itself to circulating the results of the Community research programme. But in the long term, owing to the complementary nature of this programme, this procedure would bring little profit to the Community unless it were accompanied by a far greater pooling of findings from the national programmes and by more technological exchanges amongst the industries of the six countries.

Indeed, the elimination of certain duplicate work through programme co-ordination is only acceptable if it is offset by the exchange of certain findings from these programmes.

Scientific information methods themselves require constant improvement. The efforts of the Commission and the Member States in the documentation field should be continued and co-ordinated, so as to speed up and further simplify access to information. It would probably increase their usefulness and lower the cost if they were to be extended to other sectors of technology.

Chapter III

CONJUNCTION OF EFFORTS REGARDING SUPPLY ARRANGEMENTS

1. Common supply policy

The dependability and stability of nuclear fuel supply arrangements are the main pillars of nuclear power development and, in consequence, of electricity production. The Community must therefore conduct a common policy to ensure that all users receive a regular supply, free of discrimination as regards both prices and quantities, of ores, source materials and special fissile materials from both in and outside the Community.

The lack of such a policy could have detrimental effects on the achievement of the Community's basic objectives by creating additional obstacles to the development of a European nuclear industry and engendering discrimination between users in access to resources.

The Commission, in the context of determination of the energy policy, will make concrete proposals, aimed at achieving:

—the adoption of a common policy on nuclear fuel supply arrangements;

—encouragement of the prospecting of resources in and outside the Community;

—systematic diversification of external supply sources and improvement of nuclear fuel delivery terms.

2. Industrial measures relating to supply

Following the Council's resolution of 8 December 1967, an *ad hoc* group of the *CCNR* was asked to submit a report before the end of the year on long-term enriched uranium supply arrangements. This procedure will only make it possible to distill a viewpoint from the combined opinions of all interested sectors if information is available concerning the chief economic parameters. On the basis of the *CCNR* report the Commission will put forward proposals on the subject.

The studies performed to date show that, bearing in mind the rapid development of nuclear power and the increasingly clear-cut trend towards reactor types using enriched uranium, the isotope separation capacities now existing in the United States will not suffice to cover the requirements of the Western world after 1975. It will thus be necessary for the Community to find other sources to meet its enriched uranium requirements. The question is whether the new uranium enrichment plants will be sited exclusively outside the Community or inside it as well.

The most logical solution would be to build a Community plant that enjoys the advantages afforded by the provisions of the Euratom Treaty for enterprises of Community interest. This project should give rise to industrial co-operation in the Community on a scale hitherto unknown among enterprises in various Community countries.

Furthermore, it will be advisable to take steps at Community level to ensure optimum utilisation of the fuel cycle, i.e. to have available, at the right time and in suitable capacity, fuel element fabrication plants, means of transport and irradiated fuel reprocessing plants, and facilities for disposing of and/or storing radioactive waste.

Studies will also be needed to determine the procedures for the concerted management of nuclear fuels.

Chapter IV

COMBINING OF RESEARCH EFFORTS

In the research field, the Community's tasks can be classed in three categories:

—co-ordination of research programmes within the Community;

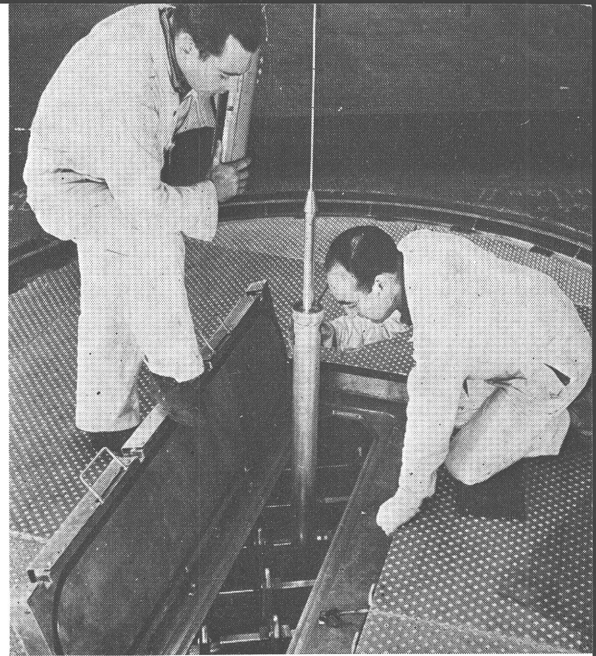
—execution of the Community's own research and development programmes;

—public service activities.

Some of these different types of activity have given rise to increasing difficulties, whilst others have afforded general satisfaction. It should be pointed out that the ones most generally recognised as useful are those that do not lead to immediate industrial exploitation. Cases in point are research on thermonuclear fusion and biology, and that conducted by the *Central Bureau for Nuclear Measurements*. On the other hand, the severest difficulties have arisen in the research connected with the development of the various reactor systems. It is, in fact, just where relatively rapid industrial results could be expected that there has been found to be duplication between the different national programmes and also between these and the Community programmes. In the case of fast reactors, certain Member States have actually several unco-ordinated programmes based on work carried out under Community projects.

Thus the desire unanimously expressed by the Member States to lay the accent on research leading to industrial exploitation has in actual practice been travestied by the opposition to the implementation in the Community of programmes dealing with precisely that type of research.

Hence the channelling of Euratom's activities into a path leading to better results from the economic and industrial standpoint can only be fully successful if an overall research strategy is steadily



A CIRENE *(fog-cooled heavy water reactor) fuel element being loaded into the* Aquilon-II *reactor at Saclay, France.*

elaborated. It would also be advisable to consider in each case whether it is preferable to develop entirely new techniques or to rely on results already obtained elsewhere with a view to exploiting them independently. The absence of a strategy of this kind has too often obliged the Member States either to keep their sights low or to try, at the price of considerable difficulties, to make good ground already lost, particularly in relation to the United States. This strategy should enable the Community to acquire an equal or even superior position in certain fields by comparison with the other major industrial States, not only in technical know-how, but also as regards industrial development.

Whilst it is important to set the targets carefully, it is equally essential, once these have been adopted, to devote the necessary efforts to achieving them uninterruptedly, so as to speed up industrial exploitation of research results.

A rational nuclear programme must not only employ the means needed to achieve the objectives in the reactor field, but also include more general research and the tasks of public interest which involve the industrial utilisation of nuclear techniques. This raises the problem of a balanced weighting of efforts within the overall programme. The desire to derive better industrial results from research efforts, evinced in recent months by the Member States and shared by the Commission, should not cause us to overlook the importance of basic research.

These problems affect national and Community activities to the same degree and their solution must therefore stem from a wide-scale co-ordination, which alone will open the way to substantially improved efficacity in the research efforts carried out in the Community as a whole.

The experience of the last ten years has clearly shown that a research community could not confine itself to a common programme and a common budget relating to limited activities. From the fact that major efforts are pursued in the Member States, it follows that a true community necessarily involves concertation of its members' efforts so as to apportion the tasks in a way which will bring the greatest profit to them all. Any other conception cannot but be diametrically opposed to the very notion of "community"; common programmes and budgets are liable to lose their efficacity if they take the form of an excrescence—constantly disputed—by comparison with other, possibly diverging, concurrent programmes.

These considerations do not apply to nuclear matters only; they also hold good for the other areas of technological research and development. The Community will have to see to it that consistent solutions are progressively worked out, the adoption of which will strengthen the overall efficiency. In particular, the "fair return" problem can only be solved by a reasonable compromise between, on the one hand, the aim of a rational share-out of research activities and their extension to the industrial sphere and, on the other hand, the desire to keep the interests of the different Member States satisfactorily balanced. Needless to say, such a balance will be the more easily determined as the range of activities widens.

Similarly, particular attention should be given to the conditions under which exchanges and contracts could be intensified between research centres, universities and enterprises throughout the Community. The inadequacy of these links, indeed, accounts in no small measure for the lag behind the United States and for the attraction exerted by the latter on European scientists and research workers. The experience acquired by the Community in establishing profitable links between research centres and industry could be used to good advantage. Furthermore, the university reforms undertaken in several Member States offer prospects which should be turned to account, especially by trying to lower or even do away with the present dividing walls.

The proposals contained in this survey are intended to initiate the progressive incorporation of Euratom's activities into the context of the common policies which —in the fields of science, technology, industry and energy—are now unanimously recognised to be necessary.

In doing this, the Commission considers that it is pointing the way to assuaging, in the area under consideration, the concern felt by the governments of the Member States.

The indispensable co-ordination of research in the Community will be ensured by confrontation of the various programmes and also by implementation of the Community programme.

Programme confrontation, if it is to be effective, involves an effort of considerable proportions, for it is not a question simply of comparing the research subjects, but of deciding what are the true motives underlying each and every one of them and what scientific, technical and economic results can be expected from it. Only a thorough analysis of this kind will provide a reliable pointer to whatever co-ordination measures and specialisations may be necessary in order to make the best use of the talents, time and resources available and to specify which projects are worth conducting at Community level. The Commission is resolved to develop this confrontation of programmes and means of execution, as it is in duty bound to do by Article 5 of the Euratom Treaty and by the Council's Luxemburg resolution.

The Joint Research Programme mapped out elsewhere maintains effective means of co-ordination, for instance, in the case of fusion and biology research.

As regards the fast and high-temperature reactors, the Commission considers that discussions must be started as soon as possible on developing structures to provide the indispensable co-ordination in keeping with the proposals formulated in Chapter II of Part II. Meanwhile, until these structures are set up, the Commission proposes that the staff be kept on in their present posts, without any prejudice whatsoever to subsequent procedures for co-operation between the Commission and the Member States. With regard to heavy-water reactors, on the other hand, the *ESSOR* reactor and allied facilities available at Ispra, which can be used for experiments on different variants, hold out prospects of substantial activity at the *Joint Research Centre*.

In addition to the activities carried on at the *Joint Research Centre*, mainly with a view to facilitating the future co-ordination of other, variously motivated, operations, certain proposals concern fields where the ultimate aims and the capabilities acquired warrant continuing or amplifying the projects in progress. This applies more especially to the proposals on condensed-state physics and direct conversion.

It is, moreover, only reasonable that the public service rôle played by the *Joint Research Centre* in certain fields should be continued or intensified. This rôle is concerned more particularly with nuclear measurements, materials-testing reactors, training, and the dissemination of information.

Lastly, for the centres to function properly there must be certain joint services, such as *CETIS*. The necessary machines and teams form a nucleus whose work could have a far wider range if certain additional means were available. Especially in the context of the existing activities, on automatic information processing or materials in particular, it might be found possible to give the Centre's activity a certain slant towards outstandingly important non-nuclear fields; however, specific proposals cannot be submitted until after a thorough study, at Community level, of the Member States' requirements and present research programmes in these fields and of the legal problems that arise in this connection.

Turning to the immediate future, the proposal which the Commission sets out in another document—which draws largely on the experience of the past ten years—should enable the Council, whilst assuming the legal obligations vested in it by the Treaty, to lay down for Euratom a research programme keyed to continuity, progressive selectivity and optimum use of resources. The Commission's proposal deals with programmes covering various periods depending on their nature, so that changes of orientation will be possible where they prove necessary. In this way it ensures that the scientific assets built up by the Community itself are utilised, and at the same time meets two basic conditions:

—the setting of medium-term targets, which alone can guarantee a minimum of continuity in the execution of projects;

—flexibility, which must be a dominant feature of any programme in so fast-moving a sphere as that of scientific and technical research.

List of abbreviations used

ACEC	Ateliers de Constructions Electriques de Charleroi
AEG	Allgemeine Elektrizitäts-Gesellschaft
AGIP	Azienda Generale Italiana dei Petroli
APDA	Atomic Power Development Asrociates
AVR	Arbeitsgemeinschaft Versuchsreaktor G.m.b.H. Düsseldorf
BBC	Brown, Boveri & Cie, AG, Mannheim
BBK	Brown-Boveri/Krupp Reaktorbau GmbH, Düsseldorf
BR-2	Belgian Reactor 2, Mol
BWR	Boiling Water Reactor
CBNM	Central Bureau for Nuclear Measurements
CCNR	Consultative Committee on Nuclear Research
CEA	Commissariat à l'Energie Atomique, France
CEN	Centre d'Étude de l'Énergie Nucléaire, Belgium
CERCA	Compagnie pour l'Étude et la Réalisation de Combustibles Atomiques
CERN	European Nuclear Research Organisation, Geneva
CETIS	Centre Européen de l'Information Scientifique, Ispra
CID	Centre d'Information et de Documentation
CIRENE	CIse REattore a NEbbia (fog-cooled reactor)
CISE	Centro Informazioni Studi ed Esperienze, Milan
CNEN	Comitato Nazionale per l'Energia Nucleare, Italy
COREN	COmbustibile per REattori Nucleari
EAEC	European Atomic Energy Community
ECO	Expérience Critique Orgel
ECSC	European Coal and Steel Community
EL-4	Heavy water reactor
ENEA	European Nuclear Energy Agency
ENEL	Ente Nazionale per l'Energia Elettrica
ENI	Ente Nazionale Idrocarburi
ESSOR	ESSai ORgel Orgel test reactor
EUREX	Enriched URanium EXtraction
Eurochemic	European company for chemical reprocessing of irradiated fuels
FFTF	Fast Flux Test Facility, USA
FIAT	Fabbrica Italiana Automobili Torino
Framatome	French-American nuclear construction company
GAAA	Groupement Atomique Alsacienne Atlantique
GfK	Gesellschatf für Kernforschung, Karlsruhe
GHH	Gutehoffnungshütte Sterkrade AG
GKN	Gemeenschappelijke Kernenergiecentrale Nederland, Dodewaard
HFR	Hoge Flux Reactor, Petten (high flux reactor)
IAEA	International Atomic Energy Agency, Vienna
INIS	International Nuclear Information System
IRI	Istituto Ricostruzione Industriale
JRC	Joint Research Centre
KEMA	NV tot Keuring van Elektrotechnische Materialen, Arnhem
KFA	Kernforschungsanlage Jülich
KKN	Kernkraftwerk Niederaichbach GmbH
KNK	Kompaktes Natriumgekühltes Kernkraftwerk, Karlsruhe
KRB	Kernkraftwerk RWE-Bayernwerk
KRT	Kernreaktorteile GmbH, Frankfurt
KSTR	KEMA Suspension Test Reactor
kWh	kilowatt-hour
KWL	Kernkraftwerk Lingen GmbH
KWO	Kernkraftwerk Obrigheim
MAN	Maschinenfabrik Augsburg Nürnberg
MASURCA	MAquette SURrégénératrice CAdarache Cadarache breeder mockup
MMN	Métallurgie et Mécanique Nucléaires (Dessel, Belgium)
MTR	Materials Testing Reactor
MWe	megawatt (electric)
MWth	megawatt (thermal)
MZFR	Mehrzweck-Forschungsreaktor (multi-purpose research reactor)
NUKEM	Nuklear-Chemie und -Metallurgie GmbH, Wolfgang bei Hanau
OECD	Organisation for Economic Co-operation and Development
ORGEL	ORGanique Eau Lourde (heavy-water-moderated organic-cooled reactor)
PEC	Prove Elementi Combustibile (fuel-testing reactor)
PEON	Commission pour la Production d'Électricité d'Origine Nucléaire, France
PFR	Prototype Fast Reactor, Dounreay, Scotland
PWR	Pressurised Water Reactor
RAPSODIE	Réacteur RApide refroidi au SODIum (fast sodium-cooled reactor)
RCN	Reactor Centrum Nederland
RDM	Rotterdamse Droogdok Maatschappij NV
SEFOR	Southwest Experimental Fast Oxide Reactor
SENA	Société d'Énergie Nucléaire Franco-Belge des Ardennes, Chooz
SICN	Société Industrielle des Combustibles Nucléaires, Paris
SNAM	Progetti Società Nazionale Amministrazione del Metano (belongs to IRI)
SNEAK	Schnelle Null-Energie-Anordnung, Karlsruhe(fast zero-power assembly)
SNR	Schneller Natriumgekühlter Reaktor (fast sodium-cooled reactor)
SOCIA	Société pour l'Industrie Atomique
SUSPOP	Dutch suspension reactor project
tce	tons coal equivalent
THTR	Thorium Hochtemperaturreaktor
TNPG	The Nuclear Power Group (United Kingdom)
USAEC	US Atomic Energy Commission
WAK	Wiederaufarbeitungsanlage Karlsruhe

General view of the RAPSODIE *fast neutron experimental reactor in Cadarache (France).*